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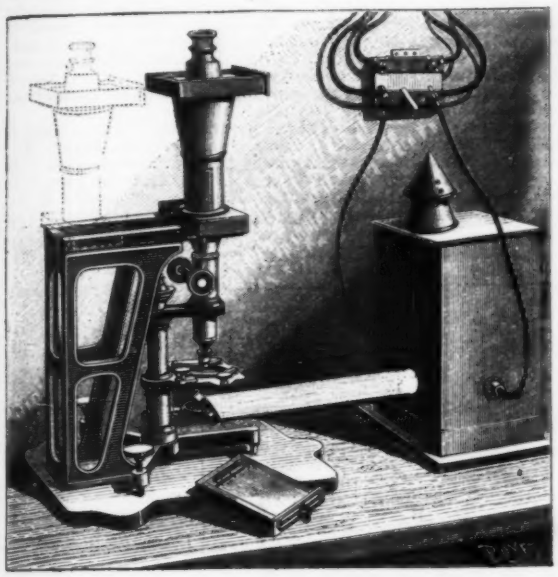
MICROSCOPIC PHOTOGRAPHY AT THE MUNICIPAL LABORATORY OF PARIS.

Since the year 1885, the Municipal Laboratory of Paris has thoroughly modified its micro-photographic plant, and has had a new apparatus constructed, which is based upon an entirely different principle. It is well known that, in the microscope, the image furnished



MICRO-PHOTOGRAPHIC APPARATUS OF THE LABORATORY OF CHEMISTRY OF PARIS.

by the objective forms in the ocular, nearly at the location of the diaphragm, united and corrected by the field glass, and that, through the effect of the eye glass, it becomes virtual, since it is formed between the lens of the latter and the principal focus.

If, at this moment, we move the microscopic preparation away from the objective, the image will proportionally approach the latter, and, consequently, move away from the eye glass, and, at a given moment, will be found no longer on the inside of the focus, but beyond it. Then we shall have a real image that may be received upon the ground glass of a camera placed in the prolongation of the microscope.

The image will be so much the better in proportion as the ocular corrects it in magnifying it, but it is rare that it can be utilized in its entirety, for there always remains some slight spherical aberrations, and it is necessary to eliminate the marginal parts through a diaphragm, in preserving, at 25 centimeters distance for example, only a circle of 7 centimeters diameter, or at 50 centimeters a circle of from 12 to 13 centimeters diameter. It is preferable to form it further off, with a camera of larger extension, than very near the ocular, for the reason that we more closely approach the conditions of ordinary vision for which the microscope has been constructed and the optical system corrected, the image being produced in the ocular as near as possible to the diaphragm.

As the amplification is realized in part by the distance, it is possible, with the same objective, to use an ocular of lower power, thus allowing less light to be lost.

The accompanying figure represents the laboratory apparatus. Upon a brick foundation, an iron plate, supported by four legs, receives a microscope stand mounted upon leveling screws, and, through the intermedium of iron bars, supports two horizontal slides upon which the metallic camera moves.

The light is furnished by a "sun" lamp, inclosed in a lantern to the right, and in which the carbons are kept at an invariable distance in the interior of a hollowed-out block of marble that the arc renders incandescent. The luminous point is absolutely stationary—a condition that is thoroughly indispensable for micro-photography, since here it is not a more or less luminous object that is reproduced upon the sensitized plate, but the projection, upon a luminous pencil, of objects that are more or less opaque, and the first condition is that such pencil shall be stationary and homogeneous. It is for this reason that it has not been possible to use magnesium to this effect. The luminous pencil, condensed by a lens, is sent to the preparation by the mirror of the microscope. Its limits are fixed by a diaphragm, and a shutter permits of arresting it on its passage and of regulating the exposure. The region to be photographed may be selected by observing as with an ordinary microscope and focusing. The camera is afterward slid over the ocular, the slide that arrests the lateral rays is closed (those coming from beneath being shut off by a diaphragm), and the focusing is effected upon the ground glass. It then only remains to substitute the sensitized plate for the latter.

It is necessary to make a correction for the chemical focus, so much the greater in proportion as the amplification is less. This is effected by means of a graduation traced with precision upon the micrometer screw.

The camera is provided with a piece, the theory of which is not yet well elucidated, and which contributes to the increasing of the sharpness of the images. This is a lens of long focus, so arranged as to nearly touch the ground glass. It doubtless acts by regularizing the divergent pencils coming from the parts of the preparation that are not exactly in focus, and renders them parallel.

This instrument has been in current use for seven years for the photographing of adulterated pepper, preserved tomatoes, flour, licorice, chocolate, etc. The amplification most employed is 210 diameters, which is obtained with a five objective and two ocular.

The use of it necessitates the setting in operation of a magneto-electric machine and a gas motor. So, when it is desired solely to keep a remembrancer of a preparation, a simpler but less stable apparatus is installed, which is all-sufficient in most cases in which the amplification does not exceed 200 diameters, and which is within the reach of all amateurs. We shall describe it.

It consists of a wooden camera (as, for example, that of Nachet) fixed between two uprights, and capable of being drawn out to from thirty to fifty centimeters, and arranged at such a height that the microscope serving for the observations can be placed under it.

A diaphragm (which, if need be, can be made of blackened sheet cork) arrests the extraneous luminous rays. The preparation is illuminated by means of an albocarbon or kerosene lamp, or, for amplifications exceeding 100 diameters, by the oxyhydrogen light. The microscope is centered with respect to the camera, and the focusing on the ground glass is effected by revolving the micrometer screw.

It is preferable to replace the ordinary ocular by the Zeiss projection eye piece, which is now constructed by Mr. Nachet. The images are thereby rendered sharper.

For amplifications exceeding 200 diameters, it would be necessary to give the apparatus greater stability, for the slightest vibrations are shown in the negative by a change of focus and shading lines with a heavy base, and, if it were possible, to mount it upon a pedestal of bricks dipped in hot bitumen, as is done for gas motors; but as it is hardly ever (except in the photographing of bacteria) that such amplifications are exceeded, it would be preferable to have recourse to the new processes applied in Koch's laboratory, and which have furnished the magnificent photographs of Frankel & Pfeiffer's atlas, and for which a special material is employed, viz., Zeiss' apochromatic objectives. These processes, entirely different from others, merit a special article, which we shall give in a future number.

INSTANTANEOUS PHOTOGRAPHS.

We reproduce herewith a few of the instantaneous photographs that have recently been sent us, and which show to what a degree photography succeeds in fixing scenes that the eye has scarcely time to perceive well during their short duration.

On the 28th of last February, while Paris was covered with snow, Mr. P. d'Abbadie, one of our readers, was crossing Batignolles Square with his photographic apparatus just as three young men were amusing themselves with snowballing each other. The appa-

Fig. 2.—INSTANTANEOUS PHOTOGRAPH OF A REARING HORSE.

ratus was quickly brought into play, and the photograph obtained, which was very successful, shows us one of the belligerents assailed by his two adversaries (Fig. 1). The motion of the characters is very entertaining.

A cavalry lieutenant of Sainte-Menehould, who desires to remain anonymous, sends us a photograph of a rearing horse which, adds our correspondent, "seems to me quite a success" (Fig. 2). Compliments, in fact, to the operator, but compliments especially to the rider, who, concealed behind his steed standing upon the hind legs, appears to us a steady horseman.

Fig. 3 is a facsimile of an instantaneous photograph representing a monocyclist. It was taken by Mr. Emile Tardieu, of Montelimar, and was obtained by means of a rapid shutter constructed by him. The photograph represents a young monocyclist, Mr. Duris, at the moment in which he was passing over the Promenade des Marronniers at Dieulefit (Drome).

Fig. 1.—INSTANTANEOUS PHOTOGRAPH OF A SNOWBALLING SCENE.

Fig. 3.—INSTANTANEOUS PHOTOGRAPH OF A MONOCYCLE AND RIDER.

HOW WOOD PULP IS MADE.

IN none of the mechanical arts has greater progress been made in recent years than in the manufacture of book and magazine paper, many tons of which are used in Boston every month. Years ago—though not too long to endure in the memory of "the trade"—the process of converting the raw material into the hard-fibered and smooth-surfaced paper essential to the needs of the higher class publishing houses was a task involving many days of constant care and much manual labor.

To-day the process is extremely rapid, the paper is infinitely better than before, and much of the manual labor that was employed in the days of our fathers has been supplanted by labyrinths of swift-moving machinery.

It would be difficult to imagine a more surprising metamorphosis than that by which the native timber on the Pennsylvania hills is converted in seven hours to a sheet of clear white paper ready for the press.

Yet this, in brief, is the process that is going on every day at a mill at Johnsonburg, in western Pennsylvania. This mill is the largest book paper making establishment in the world. It covers several acres of ground and almost as many acres of machinery.

Sixty cords of timber are thrust into the choppers and 90,000 pounds of paper are shipped from the yards every day to be cut, printed, and placed on countless library tables throughout the land.

This chopper, where the conversion of wood into paper begins, is a sort of guillotine. There is a sharp blade of massive proportions, moving swiftly in a groove. Everything that comes beneath the knife is severed.

Occasionally a tough knot that has withstood the blasts of many a winter is tossed in, only to suffer the fate of the sapling that went before. Every stick that goes in comes out in the shape of chips no longer than half the palm of a man's hand.

The wood does not lose its identity, however, until the next stage in the process, which is known as "cooking." There are several large digesters, containing caustic soda, in which the chopped wood is placed and cooked for five hours, this being the longest single process to which it is subjected. From the digesters it is blown into a large tank, its consistency being thick and heavy and its color an ugly brown.

The soda having been run out, the pulpy, cooked wood in the tank is washed down with hot water and thoroughly cleaned. Then it is dumped into a large chest, cleaned again, and, having been pumped into a screen, which removes splinters and debris, it is run into wet machines and in a measure dried.

The "stock" emerges from these machines an unbroken sheet of light brown pulp, resembling soaked birch bark. As it falls from the machines it is taken on carriages to four bleachers, each holding 4,000 pounds. Here it is treated with chloride of lime liquors until the desired whiteness is obtained.

By this time one begins to see how it is possible to make paper from wood, for the "stock" has already assumed a beautiful white color, and its consistency is of a soft pulpy sort, very much like boiled starch, and not at all like wood.

Squeezed in the hand, however, there remains a dense fiber that clearly shows the stuff of which paper is made, and establishes the link that binds the pulp in the tank to its parent timber on the neighboring hills.

A pulsometer pump, thumping away close by the bleachers, next drives the white mass into fifteen large store chests, each holding 8,000 pounds. It is held in these chests until the beating engines are ready to give it a shaking up, preparatory to its final transition. The stock, which is now called "half stock," here receives its coloring material and sizing.

If blue, yellow, pink, or any other color is desired, this is the stage in the process where the coloring material is applied. The "sizing," which consists of resin and an alkali boiled together, is used to give the paper the desired resistance to atmospheric influences.

An alum is used, which separates the alkali from the resin in minute particles, and while passing through the calenders or the paper machines, it fuses, thereby completely covering the sheet with a film, which effectually resists the influences of the atmosphere. Agolite, or clays, are also used to make the paper opaque.

From the beaters the "half stock" is passed into a large chest, holding 4,000 pounds, containing an agitator turning at the rate of twelve revolutions a minute, and thus keeping the stock in a uniform condition, preparatory to its passage to the refining engines. These engines, two in number, supply a 100-inch paper machine, which marks the beginning of the end of the metamorphosis.

Having passed through a sand catcher to a receiving or mixing box, the stock finds its way to the great Fourdrinier machines. Still in a liquid state, it is passed to an endless wire screen and a vibrator, where the water is taken from the then partially formed paper by means of three suction pumps. This screen contains seventy meshes to the square inch and is forty feet long.

By the time the stock leaves the screen its transition to the paper state is clearly defined, though there is still a long line of humming machinery through which it has to pass. The primary stages, however, are over.

A 10-inch "dandy" roller now gives the paper the same shape and surface on both sides, and, if necessary, supplies it with the water mark. Then it passes to two couch rolls covered with woolen jackets, and then to a 32-foot endless Bredt wet felt, where the remaining water is pretty effectually pressed out.

As there is some water remaining, another felt press is resorted to, and then the paper is ready for the drying cylinders, fifteen of which, each forty-eight inches in diameter, and heated by steam, relieve the paper of the last of its moisture. A cloud of steam rising from these cylinders, as they slowly revolve with their white coverings, shows that some moisture still remains.

But the cloud grows less and less dense as the last of the cylinders is reached, and by the time the paper reaches the calenders it is as dry as a bone. These calenders are chilled iron rollers, which give the paper its desired finish.

From them it passes to six revolving reels, and then to the cutting machines, where it is cut in any shape or size preparatory to shipment.

While this wonderful process is going on, the caustic soda used in cooking the wood originally is by no means forgotten. This soda is somewhat expensive, and about 65,000 pounds of it would be lost every day if it were not recovered.

Accordingly it is drained through the bottom of the tanks, to be subjected to a remarkable series of processes which eventually restore it to its original condition and to 90 per cent. of its original volume.

From the storage tanks it is filtered through sand, and then run to a boiler, where it is heated to 170° preparatory to entering the Yaryan evaporating machines.

These wonderful machines may be said to have revolutionized not only the paper-making industry, but every other industry as well in which processes similar to that of the recovery of the caustic soda are involved. The Yaryans contain 22 coils, traversing their entire length.

The liquor enters the coils at 22 different places, and travels through each "effect" five times. Then it passes out into the head, drops down and goes through into the second effect, while the steam passes out. Thus the steam rising from the hot liquors helps evaporate the liquor in the second effect, where the operation in the first effect is repeated, the steam passing around the flues and the liquor passing through them.

By the time the third effect is reached the liquor is of the consistency of molasses, containing a very small percentage of water and consisting for the most part of soda and resin.

After leaving the third effect it passes into a store tank and is drawn off into four "rotaries," which are simply revolving cylinders, eight feet in diameter, lined with fire brick. The liquor runs in at the back of these cylinders and coats the inner surface, while a natural gas flame at the front sets it afire.

In this way the resinous substances are burned out completely, so that when the erstwhile liquor emerges at the front end of the rotary it is a cherry-red ash, consisting of carbonate of soda mixed with the carbons of the burned resin.

Dropping from the rotaries to an endless chain, the ash is carried up to the leaching battery, consisting of six tanks, in which the soda is leached out of the ash by hot water.

The mill at Johnsonburg is peculiarly well situated as far as natural surroundings go, as the entire plant is supplied with natural gas, and with an excellent water supply from the Clarion River.

Twenty-two boilers effect the necessary steaming; two pumps' supply 1,500 gallons of water per minute from the river, which runs by the mill. The machinery is driven by two Corliss engines, one of 650 horse power and the other of 400 horse power.

The machinery which has been described as forming a part of the paper-making establishment *per se* is by no means all that the mill contains, but it suffices to reveal to the layman an idea of the tremendous skill involved in the production of this familiar article.—*New York Times.*

THE WOOD PULP TRADE.

THE manufacture of wood pulp is a comparatively modern industry which has developed to very large proportions. About a quarter of a century ago it was proved possible to make printing and wrapping papers from wood, and Germany rapidly obtained a wide market for paper manufactured from timber. Besides its value as an industrial product, notice must also be taken of the fact that the manufacture of wood pulp utilizes large quantities of timber which have been heretofore regarded as practically worthless. Among the countries not possessing important paper mills, but which, nevertheless, have large supplies of wood, Norway occupies an important place as a producer of wood pulp, which is exported for the use of paper makers in other countries. Of course, the introduction of such an important industry into Norway led to the establishment of similar undertakings cognate to it. Thus, of the fifty-eight wood pulp mills now in operation in Norway, ten have added paper factories to their capacity, in order to employ the raw product and export the finished paper. One has also the plant for making water buckets. The following figures, showing the exports of the wood pulp produced by mechanical means during the last five years, are illustrative of the steady expansion of the trade:

	Tons.
1887	155,000
1888	175,000
1889	190,000
1890	207,000
1891	235,000

These figures include the 50 per cent. of water, and those for 1891 represent a value of about seven million kronor. The chemical pulp or cellulose has not proved so profitable as the mechanical. In fact, the trade in this description has been almost stationary during the last two years, if a comparison of the latest export statistics is regarded as a fair criterion—amounting, as they do, to about the same in both 1890 and 1891, viz., 17,000 tons of dry pulp and 9,000 tons of ordinary, both quantities being valued at four million kronor.—*Timber Trades Journal.*

PHOTO-BICYCLE SUPPORT.

THE photographic apparatus is now tending more and more to become one of the indispensable accessories of the bicyclist's traps. So several inventors have set their wits to work to find some light, easily detached supporting arrangement that will permit of reducing the different parts of the device to the smallest possible bulk.

Our engraving represents one of the models that appears to us to best satisfy the conditions of the problem.

The leg, A, consists of three telescopic tubes, the last of which is provided with an iron point designed to be inserted in the earth. The two end tubes are provided throughout their length with grooves, in which slide two screws that are fixed to the intermediate tube, and that lodge in a slot at right angles to the grooves, so that the tubes cannot accidentally re-enter one another.

The assembling of the leg with the steering gear is clearly shown in the detail No. 3 of the figure. The vertical bar of the steering gear carries a socket held in place by a screw. A pivot, forming one piece with the socket, allows of the relative displacement of the latter and of the piece to which the leg is fixed. This latter piece is provided with an aperture into which enters the tube upon which the camera is mounted. This camera is provided beneath with a ball and socket joint, and at the top with a spirit level, by means of which the operator can cause the inclination of the camera to vary or to obtain a perfect horizontality, whatever be the respective positions of the bicycle and its leg upon the ground.

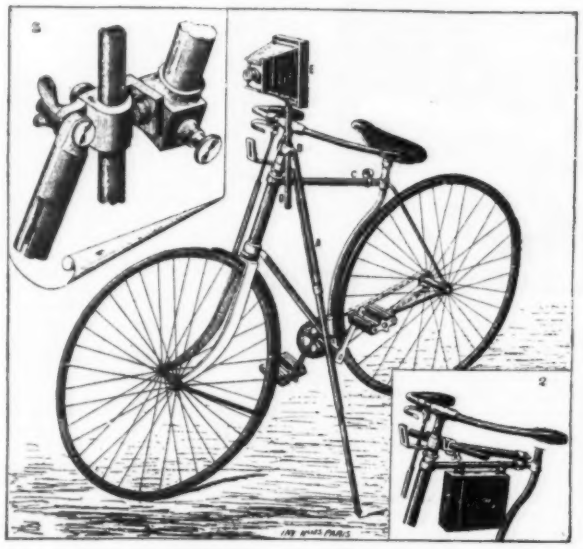


PHOTO-BICYCLE SUPPORT.

For traveling, the camera, M, is removed from its support, folded up, and fixed to the bicycle, as shown in Fig. 2, by means of straps or otherwise, care being taken to interpose small rubber cushions in order to prevent the jarring due to the motion of the bicycle from causing the camera to strike against the cross bar that supports it.

The tubes are afterward slid one into the other, the upper screw is loosened, and the tube is given a quarter revolution in order that the support, B, may take a horizontal position, and, finally, the end of the telescopic tube is made to enter the ring, C, fixed to the bicycle frame.

In this motion the socket, D, makes a quarter revolution on the guide bar, and the screw is tightened and the whole system is then ready for the trip, the leg being in the plane of the bicycle frame and the support, B, being nearly in the plane of the horizontal part of the steering apparatus, so that the wheelman is in no wise discommoded.—*Les Inventions Nouvelles.*

THE CONSTRUCTION AND USE OF THE DIPPING NEEDLE.

By D. F. MARSHALL.

IT may seem that so simple an instrument as the dipping needle, such as is used in the search for magnetic iron ore, would require no explanation, and that a mere inspection would enable one to learn all there is to be known about it. The writer's experience shows him, however, that there are many things about the instrument that only suggest themselves after long use in the field.

The instruments used by the writer were of two kinds, differing, however, but slightly—one a light instrument for prospecting, and the other a larger instru-

ment for the more careful surveying of a body of ore which had previously been roughly located.

The instrument for prospecting was made in the following manner: A ring of brass was cast ¾ in. × 1¼ in. in thickness and 4½ in. outside diameter. This was turned in the lathe, making a ring about ⅛ in. thick and having a rim ½ in. wide projecting from the inside face. This formed the compass box, and was made to insure symmetry and rigidity. The supports for the needle deserve special mention. It was found that, with the ordinary V-shaped hangers projecting from the *top* of the box only, when the compass was struck, as it frequently is when climbing over rocks, that the supports were apt to spring together and bend the pivot of the needle. To avoid this the supporters were extended to the bottom of the box and were made extra thick and heavy.

The bearings for the pivot of the needle were made of sapphire and were fastened in the ends of brass thumbscrews provided with locknuts, so that there should be no possibility of their working loose.

The needle was made of steel ⅛ in. wide, ⅛ in. thick, and just long enough to clear the rim carrying the scale.

The needle was made and accurately balanced before magnetizing. After magnetizing it was nearly balanced by filing, and then a very light aluminum rider was put on to finish the balancing and to serve as an adjuster when the needle was moved into a different latitude.

The needle is adjusted in this way: The compass is hung from a light tripod at a distance from any buildings carrying machinery, iron pipes or electric light wires, and the compass made to stand in the magnetic meridian. The needle is then adjusted to read 0°. The compass is then turned through 180°. The needle should still read 0°. If it does not, the rider should be moved until it reads 0° both ways around. After this adjustment is made, place a bar magnet directly below the compass, so that it shall show a reading of 15° or 20°, and then reverse the compass. If it does not read the same on reversing, it shows that either the bearings of the needle have been displaced or that the pivot is not at its center of gravity. In this case file off the edge of the needle.

The writer has seen a compass in use that would read 0° when held either N. or S. where there was no attraction, but would read 15° differently on reversing over a body of ore.

The handle of the compass should be provided with gimbals moving in two directions, and not, as is commonly the case, in one only. It is better to allow the needle to swing freely at all times, for when a compass needle is clamped, and is not pointing toward the magnetic north, it is liable to change the distribution of its magnetism. The dipping needle for surveying out "veins" is similar to that above described, except that it is larger, being about 5½ in. in diameter. It is also provided with a light stick, one foot long, fastened to the handle near where it is joined on to the box. This stick is made to point in the direction of the needle. On the farther end of the stick is placed a small pocket compass to indicate the direction of the magnetic meridian. This arrangement saves a great deal of time, for when moving over a body of ore, your magnetic meridian continually changes.

The method of making the magnetic survey is this: A reference line is surveyed as nearly on the line of the vein as possible. On this line stakes are set every 25, 50 or 100 ft. apart, as may be thought best. On these stakes cross lines are run out as far as the attraction extends. It is well to keep the cross lines parallel to each other if possible, even though they may not all be at right angles to the reference line. This makes a better-looking map when it comes to be plotted out. On these cross lines stakes are driven every 10, 20 or 30 ft., and observations made with the needle. An easier and quicker way is to make the observations at the tags on the tape as it lies on the ground.

The readings of the needle simply indicate the presence of magnetite, but do not indicate the quantity or quality. The presumption usually is that where the attraction is strong there is either a large body of ore or that what there is lies very near the surface.

It has been observed that when ore crops out on the surface of the ground, it is apt to be strongly polarized. A piece of polarized ore as large as one's head will cause a larger deflection of the needle than many tons of non-polarized ore. If the attraction is caused by "float" ore, it may usually be determined by holding the compass high above the ground. With large bodies of ore it makes little difference whether the compass be held near the ground or high above the head.

There are some curious things about the behavior of the dipping needle. At Mt. Olive, Morris County, N. J., there is a body of magnetite extending along the northerly slope of a hill for about a mile. The hill slopes at an angle of about 8°, and extends, as does the vein, N. 30° E. The vein dips into the hill from a line about half way down its slope at an angle of 45°. The attraction, extending from the top of the hill to the vein (about 500 ft.), increases pretty uniformly from + 3° to + 80° and 90° at the vein. From the vein down the hill the attraction decreases from — 89° to — 3° to 0° in a distance of 200 to 300 ft. There never has been any ore taken out below the line of positive attraction.

Inside the tunnel at Mt. Olive there is one point where if the needle be moved an inch one way or the other it would be completely reversed. At Port Oram, N. J., there is an area many acres in extent where the attraction is all negative. At other places the attraction is all positive.

It will usually be found that the attraction is negative for a short diftance, at least, from the center of the vein.

Absence of attraction at any point is not always a proof of absence of magnetite.—*Eng. and Min. Jour.*

CEREBRAL RADIATION.*

By Prof. EDWIN J. HOUSTON.

I HAVE thought it possible that it might interest you to consider some rather wild speculations in which I have indulged for a number of years past, but which I have heretofore refrained from publishing. In these speculations, to which I was first led by a suggestion from a friend, I have endeavored to correlate, to some extent, the phenomena of thought with grosser physical phenomena. Although the suggestions I have to offer as a basis for a hypothesis of the mechanism of cerebration are confessedly incomplete, and perhaps improbable, yet I have concluded to place them on record as of possible interest to the scientific world.

I am, of course, aware of the fact that the psychical operations of the brain are by no means understood. It is generally believed, however, that the seat of psychical activity is the cerebrum. The manner in which the brain acts to produce, record, and reproduce thought is unknown, and will probably remain unknown.

On the single assumption, however, that cerebration or thought, whatever may be its exact mechanism, is accompanied by molecular or atomic vibrations of the gray or other matter of that part of the brain called the cerebrum, I would propose the following hypothesis to account for telepathy, mesmerism, thought transference, hypnotism and other cognate phenomena.

Postulating the existence of the universal or luminiferous ether, which is now generally accepted in scientific circles, and bearing in mind the fact that this ether passes through even the densest matter as easily as water through a sieve, it follows that the brain atoms or molecules that are here assumed as the cause of cerebration are completely surrounded by the ether. Now, since the ether is a highly elastic, easily movable medium, it would follow that thought or cerebration, if attended by vibrations, must necessarily develop in the ether wave motions which have the brain atoms or molecules for their centers. In other words, the act of thought or cerebration necessitates an expenditure of energy, because it necessitates the setting in motion of these assumed atomic or molecular brain particles.

The exact nature of the motions that are assumed to attend an active condition of the brain must necessarily remain unknown as long as we are ignorant of the exact nature of the mechanism that is moved. But, if an active brain evolves thought because something is set in motion, it, of course, follows that a brain absolutely free from producing thought must be at rest so far as that kind of motion is concerned. An absolute freedom from thought in a healthy brain is most probably a condition that seldom exists; relative rest, however, must be quite common.

That the brain cells of the gray or other matter involved in the production of thought can be caused to assume certain groupings or relations toward one another would appear to follow from the ease with which that curious function of the brain called memory permits it to readily recall past peculiarities in the to and fro motions. By continually repeating certain trains of thought, as in study or repeated observations, the peculiar motions required to produce such thought are probably given a set or tendency to form more or less permanent groupings. When, therefore, the brain is moved or played upon, so to speak, these motions recur and certain memories are awakened.

How may these motions be produced? The answer would certainly appear to be both from within and without. It is, perhaps, possible that the flow of blood to an active brain, which, as is well known, attends all active cerebration, is not only for the purpose of nourishing and rebuilding the organ, but also for affording the purely mechanical force that needs but to touch this marvelously attuned organ to awaken the thoughts already impressed thereon, or to sit in judgment on new combinations never before presented to it.

I will suggest an explanation later on as to how these impressions may possibly be excited from without.

Whatever be the origin of these vibrations, or however excited, energy is required to be expended in producing them, and as the brain worker will readily acknowledge, the expenditure of such energy often calls for an enormous expenditure of nervous force.

Cerebral energy, or energy thus expended in producing thought, is dissipated by imparting wave motions to the surrounding ether, and such waves are sent out in all directions from the brain, possibly in greater amount or of greater amplitude from some of the brain openings, as, for example, those of the eyes.

Although there are no absolute proofs of the existence of the molecular or atomic vibrations of the brain particles which I have assumed, such a movement, however, is far from being improbable, and, indeed, some facts known to the medical profession are far from being at variance with such an assumption. A certain amount of pressure on the brain arising from the pressure of the blood is necessary for its proper action. If this pressure increases beyond a certain value, as, for example, in cases of fracture of the skull, where a portion of the bone is depressed by the fracture, thereby producing a compression on the brain material, all thought or cerebration instantly ceases; but when this pressure is relieved by the act of trephining, cerebration not only begins, but, curiously enough, generally goes on from the point where the patient left off when the injury occurred.

Let us assume then that cerebral radiations or waves are given off from every sentient or active brain, and that these waves pass into the space around the brain something like the waves that are imparted to the air around a sounding tuning fork.

The cerebral radiations are not so gross as those of sound. Their wave lengths are almost certainly much shorter. They are imparted to the universal ether.

If such waves, which I would call thought waves or cerebral waves, be present in ether that fills all space, it will be interesting to inquire what phenomena they might be expected to produce.

It being assumed that these vibrations take place in the ether itself, there need be no doubt or speculation as to the general nature of the waves themselves. They would presumably partake either of the nature of transverse or torsional vibrations.

The commonest character of the vibrations which occur in the universal ether are the vibrations which are now generally recognized as transmitting the phenomena of heat, light, electric or magnetic radiations, viz., of transverse or torsional vibrations.

An active brain may, therefore, be regarded as moulding the ether around it into thought waves that are spreading outward from it in all directions. In this respect it is not unlike a conductor through which an oscillatory discharge is passing, producing those waves which Hertz has so beautifully demonstrated as resembling the vibrations that produce light.

Assume, then, that the cerebral radiations partake of the nature of thermal, luminous, electric or magnetic radiations, and the following explanation of telepathy, or thought transference, is, to say the least, not improbable.

I would explain the possibility of the transference of specific cerebral vibrations from an active brain to a passive or receptive brain by the simple action of what is known in science as sympathetic vibrations.

Take the case, for example, of a vibrating tuning fork that is sending off its waves across the space which separates it from a second tuning fork, not as yet in motion, but tuned so as to be able to vibrate in exact unison with it. As is well known, the exact correspondence between the period of the active or the transmitting fork and the passive or the receptive fork is such that the vibrations of one fork are gradually taken up by the other fork, so that the energy of the motion of the one is transferred or carried across the space existing between them by means of pulses or waves set up in the air which surrounds them.

As is well known, such sympathetically excited vibrations can be produced in a fork situated at a considerable distance from the exciting fork.

Or, similarly, take the case of the sympathetic vibrations excited by waves of light. Solar energy is radiated or transferred across the space existing between the sun and the earth by waves or oscillations in the luminiferous ether. These waves, falling on the delicate structure of a leaf, suffer a species of selective absorption, certain wave lengths being absorbed and others thrown off. The absorbed waves excite or produce sympathetic vibrations in the molecules of carbon dioxide present in the leaf, and cause the atoms of carbon and oxygen in such molecules to move toward and from one another in interatomic vibrations, which increase in amplitude or violence until their chemical affinity or atomic attraction is overcome and dissociation occurs. The oxygen is then thrown from the leaf into the air, and the carbon is retained in the structure of the plant.

Or, take the still more interesting case of what Hertz calls electric resonance. As already mentioned, it is now generally recognized by electricians that a conductor which is the seat of an oscillatory electric discharge is sending into the space around it electric waves or oscillations, which travel with the velocity of light, and which are, in fact, of exactly the same nature as light itself. If these electric waves meet a circuit so tuned as regards the period of oscillation of the circuit in which they originally occurred as to be in consonance with them, electric oscillations will be set up in this circuit of exactly the same nature as those exciting it.

In view of these facts it does not seem improbable to me that a brain engaged in intense thought should act as a center of cerebral radiations, nor that these radiations proceeding outward in all directions from such brain should affect other brains on which they fall, provided, of course, that such brains are tuned to vibrate in unison with them. In such cases the absorption of energy by the recipient brain may be either a species of selective absorption, in which its train of thought is only modified, or it may be absolute, in which case the recipient brain has excited in it an exact reproduction of the thoughts of the exciting brain.

Such a hypothesis is far from improbable; on the contrary, it would appear to be carried out by a variety of curious circumstances, which have only wanted some general hypothesis to properly correlate them.

If such a hypothesis be true, then these cerebral vibrations or radiations must travel through space with exactly the same velocity of light. This is, of course, on the assumption that the vibrating or oscillating brain molecules or atoms set up vibrations similar to those of light. Of course, this equality between the velocity of cerebral wave propagation and that of light is true only for free ether. In the ether which fills the interatomic or intermolecular spaces of gross matter, or, as it is technically called, combined ether, the velocity of wave propagation varies according to the particular character of the matter with which it is associated. A retardation or decrease in the velocity of the assumed cerebral waves would doubtless be experienced while passing through the materials of the skull and head.

If thought travels along waves in the ether similar to waves of light, it would be able to travel along any path by which rays of light can pass. It can, therefore, travel along rays of light, *i. e.*, along paths in the ether through which rays of light are moving.

There is a well known experiment in hypnotism, in which the patient, placed in a state of semi or complete unconsciousness, has his brain called into a more or less active condition by the suggestions of the hypnotizer, which might seem to somewhat favor the hypothesis of cerebral radiation.

It might be interesting, in view of the above suggestions, to see whether a hypnotizer, placed in such a position as regards the hypnotized that flashes of light falling on his eyes shall afterward fall on the eyes of the patient, to observe whether or not acts of suggestion are more readily perceived by the brain of the hypnotized along such rays of light than without the aid of such rays.

If the preceding speculations be regarded as wild, and that this is true I have already granted, what may not be said as to the following?

If thought radiations partake of the nature of ether waves, then there should presumably exist in the thought radiations or waves, phenomena corresponding to the various phenomena of thermal, luminous, electric, or magnetic radiation; even the phenomena of reflection, refraction, and possibly even of dispersion of such waves would appear to be a possibility. In this connection, it is of interest to imagine the analysis or separation of a complex wave of thought into its component or elementary waves, corresponding to the separation of a beam of light, by means of a prism.

In this connection there would be a new significance

* A paper read before the electrical section of the Franklin Institute, March 1, 1892.

in the phrases "radiant with thought," or to "concentrate one's thoughts on a subject."

If thought radiations or waves partake of the nature of light, then it would seem among the remote possibilities of science to obtain—say by means of a lens—a photographic impression of such thought waves on a suitably sensitized plate, somewhat after the manner of the ordinary photographic picture. Such a thought record, suitably employed, might be able to awaken at any subsequent time in the brain of a person submitting himself to its influences thoughts identical to those recorded.

Of course, I am aware of the improbability of such a record being obtained in the near future, and of the exceeding difficulties that would seem to stand in the way of ever obtaining it.

Until we know something more definite concerning the nature of these assumed cerebral vibrations and of their lengths, we must necessarily be seriously handicapped as to how best permanently to fix them on a suitable record surface, and how afterward to cause such record surface to interpret its peculiarities to the brain. I merely throw it out as a possibility of what science may have in store for those who come after us. I would suggest, in this connection, that one hundred years ago it would probably have been regarded as quite impossible that the telephone or the phonograph could have been produced.

Such a thought record, however, if obtained, would not be an image of the thought itself, or of the particular groupings of the particles whose to and fro movements attend or produce thought, any more than the tracings of the phonograph record form an image of the spoken words. They would merely represent the to and fro motions of the ether set in motion by the thought or cerebrations.

An eye looking at such an image would not be influenced thereby. If, however, ether waves similar to those recorded could be reproduced by causing light to pass through such photographic images of the to and fro motions of thought waves, such waves might be caused to influence the brain and thereby awaken thoughts similar or identical to those recorded.

I have often amused myself with picturing a possible thought-recording machine, whereby the thoughts of an active brain might be continuously and permanently recorded on a moving sensitized film, the exposed surface of which was placed at the focus of a large lens placed in front of any one engaged in intense thought.

If, like the cylinder or plate of a phonograph or gramophone, such a record were afterward rotated at the same speed as that at which it received its impressions, under circumstances in which light passing through it is moulded into waves similar to those recorded on it, such waves when caused to act on a receptive brain should, it would certainly seem, excite therein thoughts identical to those recorded on its record surface.

Of course, it is needless for me to say that such a machine has never been actually constructed, and is still as substantial as are the speculations which I have offered you. Indeed, the probabilities against its being produced are so great that I have hesitated even to mention it.

Some experiments might be tried in a similar manner in thought transference, by holding large lenses in front of the eyes of a hypnotizer at such a distance as to converge the assumed cerebral radiations on the eyes of the hypnotized. These experiments might be tried either along with light or independent of it.

I know that many points of the hypothesis which I have suggested are quite improbable, and that I may and probably will be misunderstood by some as putting forward facts rather than a bare hypothesis.

Probably one of the most serious objections to the hypothesis is to be found in the fact that the phenomena of telepathy and thought transference are not of more frequent occurrence. This I must frankly acknowledge to be a most serious objection. I would suggest, however, that the comparative infrequency of the phenomena may possibly be explained by the presence in the human body of a shield which protects the brain or the nerve centers from the effects of cerebral radiations. It is not impossible the sheaths of the nerves act as screens to prevent the reception by the brain of these thought radiations.

Prof. Tyndall, in his work on sound, alludes to the well known fact that when sympathetic vibrations are being excited by a sounding tuning fork in any body near it, there is a greater rapidity of expenditure of energy of the fork's motion than when it was not exciting such waves. The analogue of this phenomenon exists, perhaps, in the case of the assumed thought transference. Mental energy is presumably expended at a greater rate when it is exciting thought waves in this manner than when such are not being excited.

There has often been experienced by me as a teacher a feeling of great exhaustion in taking charge of or watching a room in which a number of bright students were undergoing an examination. It is possible that the cause of this exhaustion is the rapid dissipation of energy by the cerebral radiations being absorbed by the receptive brains of the examinees. I am informed by certain physicians that a feeling of great exhaustion is experienced by them in the treatment of some cases.

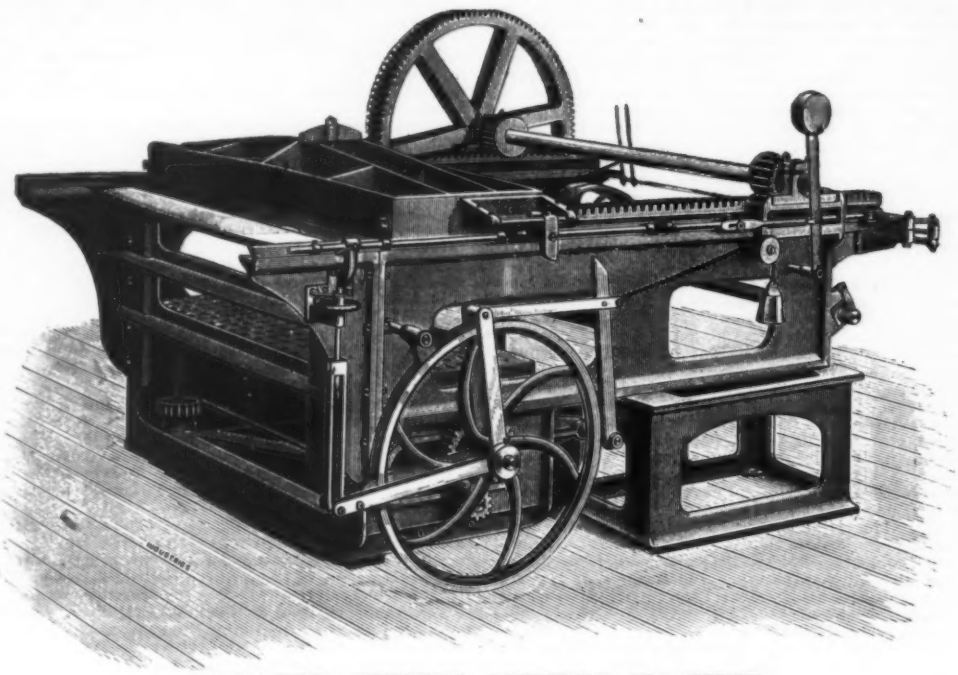
If there be any truth in the hypothesis I have briefly outlined, there should be what I would term a kind of vital radiation going on and passing outward from the body of a healthy person, which may not improbably excite by sympathetic vibrations in the bodies of weaker persons around them vibrations of a normal or more healthy type than those present in the sick person.

If this be true, the old belief of the efficacy of the laying on of hands, or of magnetic healing, may find some foundation in fact, apart from what is most probably the general explanation of such causes, viz., hysteria.

I have thrown out the above hypothesis of cerebral radiations with considerable doubt and hesitation as a suggestion only to those working in the field of telepathy or thought transference in the hope that I may thereby call the attention of such investigators to some phenomena in this very obscure field of research.

VENEER CUTTING MACHINE.

THE accompanying engraving represents a general view of an improved reciprocating knife veneer cutting machine, constructed by Pickles & Son, Yorks, which is capable of cutting veneers up to 7 feet 6 inches long and 3 feet wide. The knife is fixed at an angle to a massive sliding box, which travels in slideways on the top of the main frame, and is operated by strong bevel and rack and pinion gearing. A heavy platform in the interior of the machine, capable of vertical movement and operated by suitable mechanism, carries the timber to be cut up, which is held by cramp plates. The veneers are fed up through the opening in the heavy sliding box, and are formed in a somewhat similar manner to a shaving in a joiner's plane. From 8 to 120 veneers per inch can be cut by this machine at a speed of from 7 to 10 per minute. The weight of the machine complete is about 10 tons.—*Industries.*



IMPROVED VENEER CUTTING MACHINE.

MACHINES FOR BALING SHEET SCRAPS.

THE engraving shows a new machine for dealing with all kinds of "light iron," in order to prepare it in a portable and solid form for the furnace, either for steel melting, or for heating and rolling only. The illustration is made from a photograph of a machine designed by Mr. R. R. Gubbins, of Belvedere, Kent.

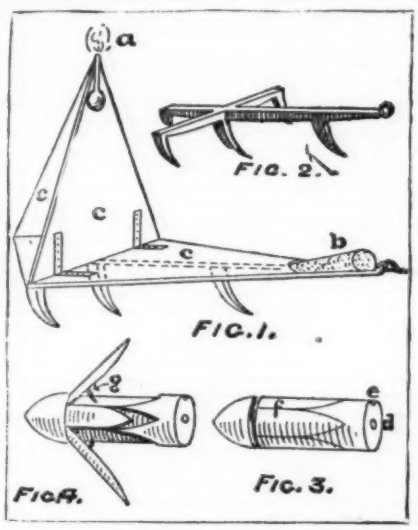
The action of the machine is very simple. Moulds the size of the required "piles" are made secure round the rim of a revolving circular table, in a somewhat similar manner to a brick machine. When filled the table is caused to revolve, and bring the full mould under a drop hammer, a few blows of which compress the material solidly together. As each of the moulds becomes filled, it is emptied again of the "piles" in the manner shown. This machine, it is stated, will bale a ton of light iron per hour with three attendants and a hammer driver, bringing the scrap up to the value of "heavy iron" at a cost of about 2s. per ton. The ham-

GUBBINS' PILING HAMMER.

mer itself weighs 15 cwt., and falls on an anvil weighing 6 tons. The blow may, of course, be varied by altering the weight of the hammer and adjusting the lift by blocking up the standard. The moulds shown are for making piles 20 in. by 7 in. by 10 in., which sizes, when properly baled, should weigh about 1¾ cwt.—*Industries.*

LIFE SAVING DEVICES.*

MR. R. J. RUSSELL aims at meeting all possible combinations of circumstances under which a wreck can take place. If the vessel was on a lee shore, a parachute would be sent ashore or the man in the life dress would go. A man could also go in the dress if the wind was off shore. In the sketches from the drawings, Fig. 1 shows, at A, a spring gun adjustable to any angle, having a wheel with handles on the rim for drawing back the spring, which is released by a trigger. The gun is attached to the mast or any convenient support. It is not intended to be a heavy affair, but such as a man could carry, and fix say 40 ft. above the deck if required. It is to be used for throwing the bolt, A, clear of the rigging and ship, and well up in the wind. A jerk of the line will open the ribs, and it will then form into the shape of an umbrella and will be carried ashore either on the wind or the waves, as at B. It might also be used to drag ashore a man in the specially designed life dress. Fig. 2 shows this life dress. The inventor says it will have an inner and outer skin of waterproof. Part of the outer skin is removed to show the means needed for protecting the limbs from injury from rocks and other dangers. It will be seen that between the skins are a series of bent wood rings, something similar to those in use for corn measures, combining strength with lightness. Some rings would have to be specially shaped for the knees and elbows. The rings can be arranged sufficiently close to almost entirely envelop a man in wooden armor and also give freedom of motion for walking and stooping. The rings would be secured in their places by the inner and outer skin being riveted to them. Vertical plates of cork could also be arranged around the body after the manner of a cork belt, and the rings above and below the elbow and knees could be held together by vertical staves if necessary. The man



FLOATING ANCHORS AND GRAPNEL SHOT TO CARRY LINES.

(From sketches by Mr. A. W. Fawcett.)

could carry a line and take a grapnel ashore with him. One of the two points on the shoulders is for spare grapnels to be fixed, the other is where a paddle could be slung for paddling ashore. The hooks in the hand would assist in climbing rocks, as would the hook in the paddle. The life dress, Mr. Russell adds, is to be large enough for a man in his ordinary sea clothes and boots to get in, and, pulling the hood over his head, be ready for action.

Mr. A. W. Fawcett distinguishes between apparatus for use on a flat coast and that fitted to render help where the coast is rocky and hilly. The design for use on a flat coast is that shown at Figs. 1 and 2. The anchor is sketched at Fig. 2. It is of steel, strongly made, and when ready for use would be supported on a stout oak float with pointed nose, and rising into triangular shape. The dotted lines indicate the place of the anchor and C the float. At A would be a tube or bulb for carrying a petroleum flare. B would be a cork float, which is intended to buoy the weight of a stout rope the float might carry. The weight of the anchor, the designer says, would make the float self-righting, and the surface it presented to the wind would hasten its arrival on shore.

The other design for use on a hilly coast is a grapnel bolt to be fired from a cannon. It is made with flanges which open and shut. In Fig. 3 is shown the shot with the flanges close to the sides, so that it may be placed in the cannon. At E is indicated where a groove would lie to carry out past the mouth of the gun the rope fastened at D. The shot is shown at Fig. 4, out of the gun, G being one of the springs which cause the flanges to open. The intention is that, when the shot reaches land, the open flanges will foul among the rocks on the rope being hauled in.

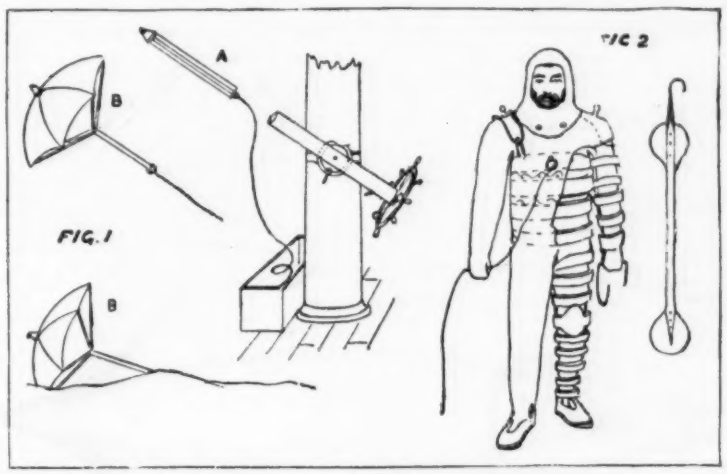
Mr. H. Massey says his design is that of a flat-bottomed paddle boat with grappling iron worked by a spring, and paying out a buoy line. He claims for it light draught, no "withholding power," and compactness. That is all he says.

The invention sent by Mr. J. D. Hickman consists of a kite made of sheeting or other suitable material. The frame is of light corrugated steel or light wood, hinged in such a manner that it can be packed in small compass for transit. The tail is composed of a flamer

* Continued from SUPPLEMENT, No. 862, p. 13774.

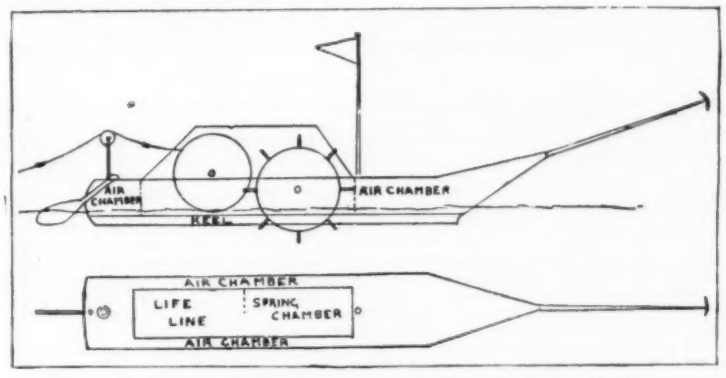
or light for night signal, which would burn for say half an hour, with a small grapnel on the extreme end. The kite has two lines, connected together by means of S hooks. These hooks are made fast to the top line at about ten feet apart. This line is of a light nature and flies the kite. The second line is of a very pliable metallic make, and is fixed to the tail of the kite. It runs free through the other eye of the S hook. When the kite has gone as far as required, tension is placed upon the second line, which "reverses the angle of the kite and causes it to come to earth." The grapnel would fix it to the ground.

Mr. J. F. Lumsden advocates the rocket, on the grounds that it has advantages over anything fired from a mortar or gun. The firing of a rocket causes little or no jerk on the line it carries, and it also acts as a signal of distress. Another advantage, he says, is that the rocket costs little and is easily carried by all ships. His scheme is a modification of the ordinary rocket. A in the sketch represents a barbed arrow-shaped head of the grapnel, made of steel, weighing say 26 lb.; the total weight of the rocket being 40 lb. B is the rocket case, made similar to the ordinary coastguard rocket, only larger. C is the rocket stick. At D is a sunken ring bolt, to which would be made fast a wire rope, E, say six fathoms long (let into the



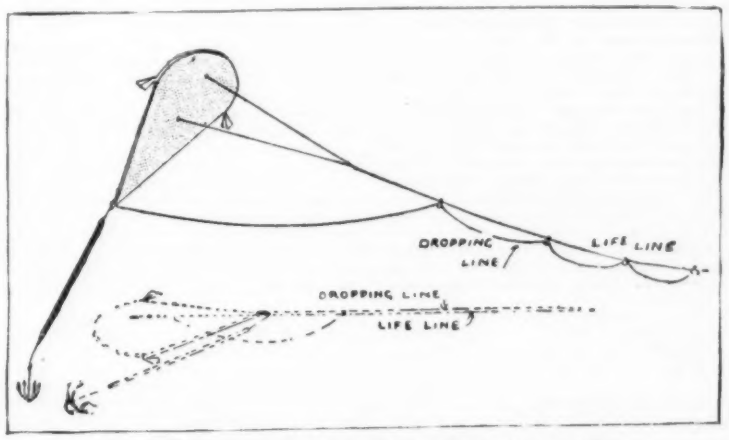
A COMBINATION—PARACHUTE, SPRING GUN, AND NOVEL LIFE DRESS.

(From sketches by Mr. R. J. Russell.)



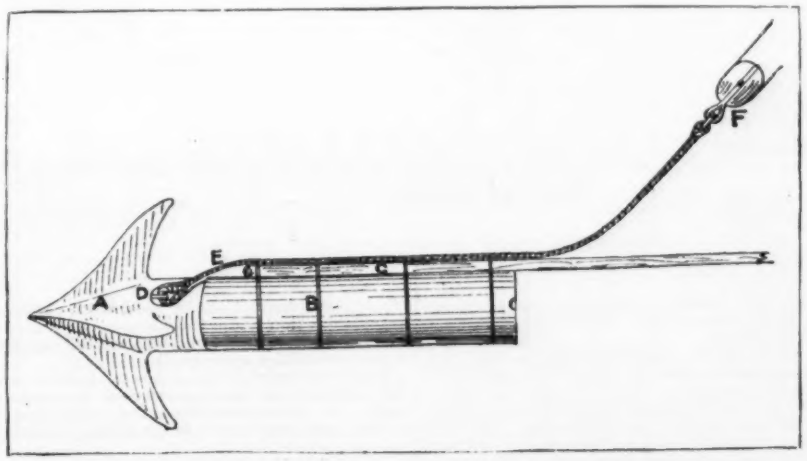
A PADDLE BOAT TO CARRY LIFE LINE ASHORE.

(From sketches by Mr. H. Massey.)



A KITE TO BE "DROPPED" FROM THE SHIP.

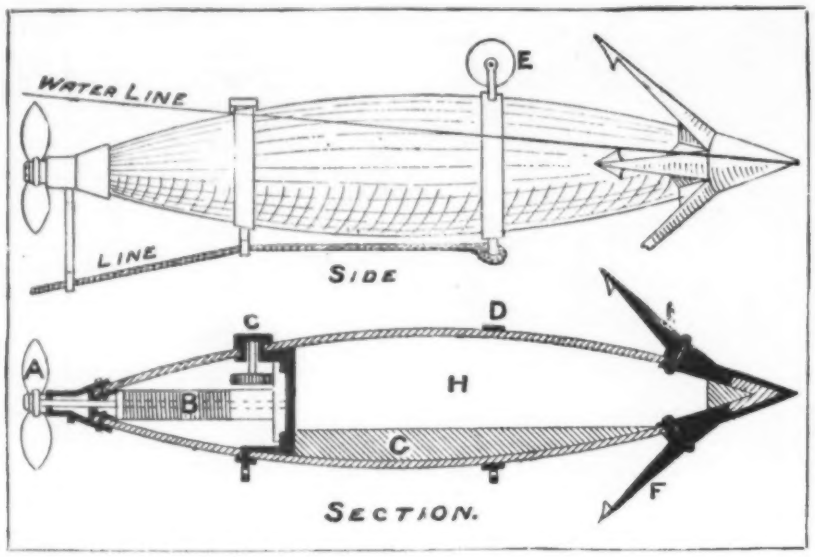
(From designs by Mr. J. D. Hickman.)



A ROCKET GRAPNEL. (From a sketch by Mr. J. F. Lumsden.)

groove shown), with a swivel block, F, at the end, having the ordinary rocket line rove through it. The rocket, in falling, would bury itself in the ground sufficiently deep to bear a considerable strain.

Mr. H. T. Edwards, in sending us his sketch, says his object has been to devise something as simple as possible, any complicated arrangement at the time of a wreck being out of place and impracticable. He, therefore, thinks a description of so simple a machine is unnecessary. The case of the machine would be of oak or other suitable wood, with metal band and fittings, and the motive power might be derived from a powerful spring or electricity. The references to the

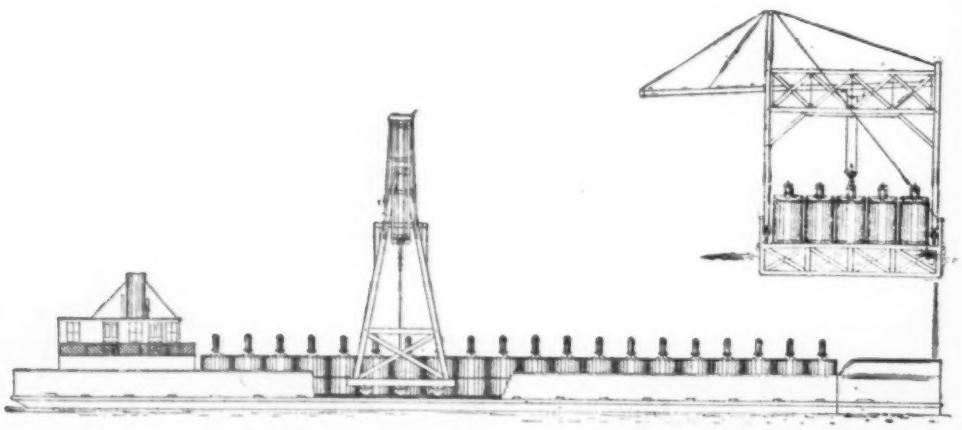


A LIFE LINE CARRYING MACHINE. (From a sketch by Mr. H. T. Edwards.)

sketch are: A, screw; B, coil spring and necessary apparatus, electric or otherwise; C, hole for winding, with cap to screw on; D, metal bands; E, signal; F, grapnels; G, ballast; H, air chamber.

STEAM BUCKET BARGE FOR FUELING BUSINESS.

OUR engraving shows the plans of the Ludlow Manufacturing Company, of Cleveland, for a bucket barge to be operated in connection with the business of furnishing soft coal for fuel to steamers on the St. Clair and Detroit rivers. This company is now making in large numbers soft coal buckets of the Ludlow pattern, which open at the bottom, and are being adopted by the trade mainly on account of a great saving from breakage in the coal. Buckets of this pattern made lately are of five tons capacity, and as they are working very satisfactorily, it is proposed to bring them into service on the Detroit River, for the same reason that has made them a success in the cargo business, viz., a saving from breakage in the coal. Although definite arrangements have not as yet been made for entering into the river trade, it is proposed to construct a steamboat about 180 ft. long, 35 ft. beam, and 8 ft. deep. The buckets of large capacity could be loaded at Ohio ports, placed entirely on deck of the light daught boat and delivered to dealers along the rivers. A derrick for handling the buckets will be placed on deck, as shown in the drawing, with drums in the engine room. The derrick will have an arm capable of putting the buckets 25 ft. back from the edge of the dock, and it is planned, of course, to have the supply sufficient so that the steamer making regular trips would replace empty buckets by loaded ones as demanded. A boat of this kind, capable of making 9



STEAMBOAT FOR RIVER FUELING BUSINESS.

or 10 miles an hour, could, it is thought, run alongside steamers in the rivers and put fuel aboard them without the slightest delay.

With the large buckets referred to here, a single derrick now being operated by the New York and Cleveland Gas Coal Company, on the Cleveland and Pittsburg Railway docks, Cleveland, is capable of loading a vessel of 2,000 tons capacity in a single day. The derrick is of the revolving and self-propelling pattern, large size, and can be worked regularly at 200 tons an hour.—*Marine Review.*

THE MICROSCOPE'S CONTRIBUTIONS TO THE EARTH'S PHYSICAL HISTORY.*

MEN will have forgotten much when the second half of this nineteenth century is no longer remembered. Whatever may have been its faults, it has no rival in the past history of the world as an epoch of scientific progress. This progress has been largely due to the felicitous co-operation of the mind of the student with the skill of the craftsman in the more perfect construction of instruments of research. By them darkness has been made visible; the opaque, translucent; the unseen, conspicuous; the inert, sensitive; silence, vocal. A thousand methods of experiment, tests of the most delicate nature, have been devised, so that vague conjecture has been replaced by exact knowledge and hypothesis by demonstration. In such an epoch it may seem a little fanciful to select any one term of years as exceptionally fruitful; but it is remarkable that in the first decade of this half century science was enriched by three contributions, each of which has led to consequences of far-reaching import. In 1858 Charles Darwin and Alfred Russel Wallace announced simultaneously the conclusions as to the origin of species at which they had independently arrived, and the well-known book by the former author appeared in the following year.

They thus formulated the results of protracted investigations and patient experiments with the simpler appliances of earlier days. They subjected, more strictly than ever before, the facts of nature to an inductive treatment and thus lent a new impulse to biological science. Their hypothesis gave a definite aim to the researches of students, and kindled an unquenchable flame of intellectual activity.

In 1860 Bunsen and Kirchoff announced the results of applying the spectroscope to problems in chemical analysis. By means of this instrument not only have investigations attained a precision hitherto impossible, but also the student, no longer cribbed, cabined, and confined to the limits of the earth, can question the stars in their courses, and bid nebulæ and comets reveal the secrets of their history.

Lastly—though the problem be in a humbler sphere, dealing with neither the immensities of stellar physics nor the mystery of life—Henry Clifton Sorby, in 1856, described the results of microscopic investigations into the structures of minerals and rocks. Strictly speaking, indeed, the method was not wholly novel. So long since as 1827, William Nicol, of Edinburgh, had contrived to make sections of fossil wood sufficiently thin for examination under the microscope; but the device, so far as I know, had not been generally applied, or its wide possibilities apprehended.

You have heard in this place on former occasions of the triumphs of the spectroscope in extra-terrestrial space; of the revelations of the microscope in regard to the least and lowest forms of life; I have ventured to ask your attention to-day to the work of that instrument in a humbler and more limited field—the constitution and history of the earth's crust. My task is beset with difficulties. Did I address myself to experts, these would be but a small portion of my audience; if I speak to the majority, it will be hard to make intelligible a subject bristling with technicalities. Moreover, as this building is so ill-suited for the usual methods of illustration, I have decided to dispense with diagrams or lantern slides, and will try to tell, in the plainest language at my command, the conclusions as to the genesis of rocks and the earlier history of the earth to which the researches of the last few years seem to be tending.

I have excluded from my story investigations which bear upon the biology of the past, though the work of the microscope in this field has not been less fruitful or interesting, because these are more widely known. Moreover, they have not specially engaged my attention, and there is, I believe, an expectation amounting to an unwritten law, that whoever has the honor to occupy my present position should be so far egotistical as to talk of the particular plot, however small it may be, on which he has labored in the garden of science. So I will crave the indulgence of the few experts present, and the patience of the majority of my audience, while I try to tell the story of microscopical research into the history of the earth's crust.

Twenty years ago, I believe, not half that number of geologists in the British Isles made any real use of the microscope. Now they may be counted by scores, not only in the United Kingdom, but also in every civilized land. Obviously in a science so new, in a research which is extending so rapidly, much diversity of opinion must exist on some theoretical questions. Into the details of controversies it is not my purpose to enter, but I shall content myself with indicating the conclusions to which I have been led in the time which the many inevitable duties of life permitted me to devote to this branch of geology.

Before doing this it may be well to indicate very briefly the mode in which the microscope is applied to the examination of rocks. Commonly it is as follows: Slices, cut by the lapidary's wheel from minerals or rocks, are ground down smoothly till they are about one-thousandth part of an inch thick, and are then mounted on glass. By this means most minerals, including the great majority of the ordinary constituents of rocks, become translucent, if not transparent. They are then examined under a specially constructed microscope, fitted with Nicol's prisms and other contrivances for optical tests. Occasionally also certain chemical tests can be applied. To what extent an object is magnified depends on the nature of the investigation. A very minute crystal can sometimes be studied, under favorable circumstances, when enlarged to at least 800 diameters; but in ordinary cases, where the chief constituents of a rock and their mutual relations are the object of research, a magnification of from 50 to 100 diameters is commonly the most advantageous. Sands, clays, and incoherent materials can be readily studied by mounting them temporarily or permanently on glass; sometimes, also, good work can be done, and time saved, by crushing up fragments of minerals and of rocks, and by treating the powder thus obtained in the same way. Investigations which promise to throw light on the problem of the development of minerals have been recently made by examining the insoluble residues of those rocks which are chiefly composed of carbonates. Solutions of different specific gravities have proved very useful in the determination of the mineral constituents of a rock, which are sorted out by them, as by a strainer, from a sand, mud, or a powdered mass, so that each kind can be studied separately either by microscopical or by chemical analysis.

The subject evidently, in process of time, tends to divide itself into two branches: the one concerned mainly with the characters of the individual constituents of a rock, the other with the wide problem of their mutual relations, or, in other words, with the history of the rock mass; branches properly denoted by the words *petrography* and *petrology*, though these terms are often confused. The former is more strictly a department of mineralogy; the latter a department of geology. This it is of which I chiefly speak to-day; this it is in which the most marked advances have been recently made.

How great these have been may be more readily appreciated if I mention a few matters concerning which, even a quarter of a century since, great uncertainty prevailed. Though it was then generally admitted that one great group of rocks, such as clays, sandstones, limestones, etc., were sediments, and that another great group, the rocks called igneous, had solidified in cooling from a fused condition; the origin of a third and by no means unimportant group, the crystalline schists and gneisses—the metamorphic rocks as they were commonly called—was considered very doubtful. Many geologists also believed that not a few igneous rocks had been once sediments, like those in the first group, which had been subsequently fused or "digested" by the combined action of heat, water and pressure. Thus it was supposed that clays and feldspathic sandstones could be traced through various stages till they became granite, and rocks of the most diverse chemical composition could be transmuted one into the other. The province of metamorphism was the fairy land of science: it needed but a touch of the magic wand, and like Bottom, the weaver, a rock was at once "translated." It would be easy, were it worth while, to enumerate instance after instance of these alleged transmutations, every one of which has been proved to be groundless. No doubt, even at the time named, these assertions were questioned by some geologists, but that they could be made so confidently, that they could be inculcated by the official representatives of geology in this country, shows the hopeless confusion into which petrology had fallen.

By means of the microscope also much light has been thrown upon the history even of the better known rocks. The classification of the igneous group has been simplified, and the relations of its several members have been determined. The microscope has dispelled many an illusion, and reduced a chaos to order. In regard to the sedimentary group, it often has determined the true nature of their constituents, and has suggested the sources from which they have been derived or the agents by which they have been transported. Thus, through its tube, we have been enabled

* The Rede lecture for 1892, delivered before the University of Cambridge, by T. G. Bonney, Sc.D., F.R.S.—*Nature.*

not only to gaze at the most intimate structure and composition of rock masses, but also to catch glimpses of the earth's physiography in ages long before the coming of mankind.

But in speaking of the services rendered by the microscope, I must not forget a needful caution. If the instrument be employed for petrological rather than petrographical purposes, it must never be divorced from work in the field. No training in the laboratory, however complete, no research in a library, however laborious, can of themselves make a petrologist. No question can be completely mastered, unless it be also studied in the field; nay, even the specimens for examination under the microscope, as a rule, should be collected by the student himself, and the characters and relationships of the rock masses from which they are detached should be carefully noted. It was said, on no mean authority, some fifty years since, that, in the education of a geologist, travel was the first, the second and the third requisite. Perhaps the statement, like most epigrams, was somewhat one-sided, but the truth in it has not been diminished by the increased perfection of our instrumental methods. In petrology, the chimeras of the home-keeping student of the laboratory have been, and still are, as hurtful to progress as the dreams of the peripatetic geologist, whose chief appliances are a stout pair of legs and a hammer.

This, then, was the problem which, some thirty years since, presented itself to geologists who were interested in petrology. Here are two groups of rocks, the sedimentary and the igneous. The origin of these we may be said to know, but as to that third group, which though not as large is far from unimportant, what is its history? what are its relations to the other two? The records of its rocks at present are illegible. Is there any hope that success will reward the attempt to decipher them? Time and perseverance have given an answer, and though much is still uncertain, though much remains to be done, some real progress, in my opinion, has been made. As the stones sculptured of old by the hand of man are yielding up their secrets, as the hieroglyphs of Egypt and the cuneiform characters of Assyria are telling the tale of the conquerors whose bones are dust, as the tongues of the Children of Heth, and of the black-headed race of Accad, are being learned anew, so the records of the rocks, wherein no trace of life is found, are being slowly, painfully, but ever more surely deciphered, and knowledge grows from year to year.

To obtain success the problem must be attacked in the following way. As the first step, the two great groups already mentioned, the origin of which is known, must be thoroughly studied. The examples selected must be nearly or quite unaffected by any agent of change, such as heat, water, and pressure. Among the specimens representative of the sediments, the materials must range from fine to coarse—for the grains in the latter serve also as samples of the rocks from which they have been broken, and suggest their own inferences. Among the igneous rocks, types ranging from the most glassy to the most crystalline forms must be examined, in order to ascertain not only the constituent minerals, but also their associations and mutual relations. Suppose this done—suppose a fairly good idea obtained of the characteristic structures and possible variations in either class—we have then to ascertain how far and in what way each representative can be modified by natural agencies. At the outset, probably, it will be found convenient to trace the processes of mineral and even of structural change without any immediate reference to the efficient cause. It soon appears that in the case of minerals which differ in physical properties but not in chemical composition, the one species replaces the other, the less stable gradually altering into the more stable form. Thus calcite takes the place of aragonite, hornblende of augite; one mineral may be broken up into a group, as a colloid into crystalloids, or feldspar into quartz and white mica; new species may be produced by addition or subtraction of constituents from without, or by exchange from within; the replacement of silicates by carbonates, the conversion of granite into tourmaline rock, the formation of epidote, chlorites, and serpentine are a few among the many instances of this kind of change. By tracing the process from one part of a rock to another, numerous facts are collected and relationships ascertained. But during these investigations questions are raised in a student's mind which begin to clamor for an answer. Why does such and such a rock change, now in this way, now in that? So it becomes necessary to correlate our observations, to frame hypotheses, and open new lines of inquiry.

So far as we know, water, pressure, heat, are the main agents in producing change in rocks, after the latter have been once deposited or solidified. In most cases it is not easy to insulate perfectly the effect of each agent, for probably every rock which has undergone important changes has been to some extent affected by all of them. Still many examples can be found in which the influence of one has predominated greatly over that of the other two. For instance, it is now agreed that the structure of a slate is the result of pressure, though this probably produced a slight rise of temperature, and the rock is not likely to have been perfectly dry. Again, when a clay has been converted into an assemblage of crystalline silicates in the vicinity of an intrusive mass of granite, this is mainly the effect of heat, though the pressure cannot have been inconsiderable, and the presence of water is almost certainly essential.

Thus, in one series of examples, properly selected to illustrate the slaty rocks, we can watch the development of new minerals. We can observe which of these are readily produced and quickly attain to a considerable size, which are more slowly formed, or seem incapable, even if common, of much enlargement. We are thus led by inductive processes to conclusions as to the effects of pressure in the development of minerals in a mass of materials of a particular composition. In another series of rocks which has been affected by the heat of intrusive masses, we can watch the gradual growth of new constituents, as we proceed inward toward the originally heated mass, till we have passed from clay or slate to a crystalline aggregate of minerals such as quartz, micas, andalusite, staurolite, and garnet. Similar effects may be noted in other kinds of sedimentary rock. Changes also are produced mainly by the action of water, but on this I need not enlarge.

Again, as another line of inquiry, the effects produced on igneous rocks by the same agents must be studied. Here the results which are more or less directly due to the action of water are often highly interesting, but as these are only indirectly connected with the main subject of this lecture, I content myself with a passing reference. With igneous rocks the effects of heat seem generally less important than with sedimentary, probably because the mineral constituents of the former are usually in a more stable condition than those of the latter, so that these also need only be mentioned; but the effects of pressure in some cases, especially with the more coarsely crystalline igneous rocks, are highly interesting and significant.

In a region such as the Scotch Highlands or the European Alps the rocks, in the process of mountain making, have been obviously subjected, perhaps at more than one epoch, to tremendous pressures. The effect of these appears to have been sometimes a direct, sometimes a shearing fracture; that is to say, a mineral or rock, in the one case, has been crushed, as in a press, in the other, during the process of powdering it, it has been dragged or trailed out, with a movement somewhat similar to that of a viscous substance. As an example, let us take the effects produced in a granite by crushing. The grains of quartz are broken up, the crystals of feldspar are first cracked and then reduced to powder; the mica flakes are bent, riven and tattered. By pressure also the solvent power of water already present in the rock is increased; by the crushing its access to every fragment and its subsequent percolation are facilitated. Thus the black mica is often altered in various ways; the feldspar dust is changed into white mica and chalcedonic quartz; the constituents are reduced in size and tend to assume a roughly parallel order; the mineral character and structure have been alike changed; a massive rock has been replaced by a foliated one; a coarse granite by a fine grained quartzose or micaceous schist. This change can be demonstrated at every stage. It suggests that many foliated rocks—many gneisses and crystalline schists—may be igneous rocks of which both the mineral character and the structure have been modified by pressure.

We may presently see how far this inference can be justifiably extended, but, as a first step, the effect of pressure on one of the more basic igneous rocks must be considered. Let us take as an example a coarse-grained variety of the rock, which is familiar to us as basalt. It consists of a feldspar, different from that of granite, of augite, of some iron oxide, and perhaps of olivine. In studying this rock we are confronted by greater difficulties, for, of the two dominant minerals, the feldspar is rather less stable than that which occurs in granite, and the augite passes readily into hornblende. Thus, when the latter change occurs we are first unable to determine whether it is due to pressure or to some other agent. Some petrologists, I believe, would not hesitate to appeal to the presence of hornblende in a rock such as we are considering as a proof that it had been modified by pressure. With this opinion I cannot agree. On examination of the numerous instances in which we are convinced that the hornblende is not an original constituent, but has replaced augite, we notice that the former mineral is not constant in its characters. It may be granular in form; it may assume its usual crystalline shape; it may be more or less bladed or needle-like. Have these differences, we ask, any significance? In order to answer the question, specimens of hornblendic rocks must be sought in regions which obviously have been subjected to tremendous pressure, as is testified by the fact that every other rock has been more or less crushed or rolled out; others must be obtained from regions where the associated masses exhibit no signs of extraordinary disturbance, even though they may be more brittle than the subject of our study. In the former case the change may be reasonably attributed to pressure, in the latter it must be due to some other cause. Are hornblendic rocks from the one region similiar in structure to those from the other? By no means. Where no evidence can be offered in favor of pressure, there the hornblende either retains wholly or almost wholly the outline of the mineral which it has replaced, or else assumes its normal prismatic form; but where an appeal to pressure seems justifiable, we find that the hornblende appears as unusually elongated prisms, blades, or even needles, and the structures of the rock as a whole can be readily recognized by a practiced eye. The evidence for the latter statements is yet unpublished, but it will, I hope, appear before long.

So our investigations have led us thus far: that, in sedimentary rocks, in the presence of water, certain changes are mainly produced by heat and certain by pressure. In the latter case, however, the new minerals, though very numerous individually, are generally minute; the longest diameter being seldom so much as one-hundredth of an inch. Even where this rule is broken, it is only by minerals which are proved by other experiments to be so readily developed that their presence on a large scale has no real significance. The rule holds also to some extent in the case of crystalline schists produced by the crushing of crystalline rocks, markedly in the case of those derived from granites and rocks of similar composition, but less conspicuously in those which were originally augitic or hornblendic. Though even here, where the decreased size of the minerals is less uniformly marked, new and distinctive structures are assumed.

I have spoken only of two or three common types of rocks, but it would be easy, did time permit, to support the principles enumerated, by quoting from a great variety of examples. There are, I believe, few, if any, important kinds of rock which have not been examined, and it appears to me demonstrated that, while pressure is a most important agent of change,* while many schists may be regarded as resulting from it, a considerable group remains which are separated from the others by a very wide chasm, and this can only be jumped by deserting reason and trusting hypothesis.

In this last group of rocks (supposing no disturbances produced by subsequent pressure, for which, however, we can generally make allowance) the constituent minerals are commonly fairly large—say from about one-fiftieth of an inch upward in diameter. Very many of these rocks, when studied in the field, exhibit every indication of a sedimentary origin. Though as a rule no original constituent grain can be certainly determined, though they are now crystalline, yet their general structure and association are inexplicable on any other supposition. They bear some resemblance to the sediments which have been altered by contact metamorphism, though they present different characters. These, moreover, remain invariable through considerable thicknesses of rock and over wide areas. The alteration is regional, not local, so that such rocks cannot be regarded as cases of simple contact metamorphism, even though heat may be suspected of having been an important agent in producing the change. But to another large series, including many of the rocks commonly called gneisses, the sedimentary origin is less easily attributed. Not a few of these in mineral composition correspond with granites, and sedimentary rock thus constituted, though not unknown, is rare. The minerals commonly exhibit a parallel or foliated and not seldom even a banded arrangement; in the latter case the layers of different mineral composition in their mutual relations and associations imitate with remarkable success the structure of a banded sedimentary rock. Even a dozen years since little doubt was entertained that this group also had a detrital origin. Occasionally, however, its members, when studied in the field, exhibited characteristics which were difficult to explain on any such hypothesis, and presented resemblances in habit to certain crystalline igneous rocks, from which, however, they were proved to differ in their microscopic structures.

In rocks which have crystallized from a state of fusion some of the mineral constituents usually exhibit their proper crystalline outlines; but in these others the same minerals had no definite shape, and were simply granular. Of this structure two types were observable; in the one the grains were elongated, in the other they were roundish in outline but slightly wavy or lobed. The former type was commonly found in the more distinctly banded varieties; the latter in the more massive and faintly foliated kinds which in hand specimens were not readily distinguished from true granite.

As in rocks, no less than in living beings, diversities of structures are nature's record of a difference in history, it became a question whether these peculiarities were significant of origin or of environment. By prolonged observations the following results were established: (1) That crystalline rocks, which could be proved, by their relation to others, to be truly igneous, sometimes exhibited banded structures. (2) That these structures, in certain cases, could not be attributed to any subsequent pressures or crushings, for no sign of them could be found in neighboring rocks, which, from their composition and nature, ought to have yielded more readily. (3) That a faint foliation or banding, especially in the case of granitic rocks, could be sometimes detected in irruptive veins, in which cases the aforesaid granular structure was detected on microscopic examination. (4) That cases were occasionally found where a light colored granite had broken into a dark hornblendic rock, and the fragments of the latter had been gradually softened, elongated, and even drawn out into bands, together with the intruder, till they perfectly simulated, as already mentioned, a stratified mass. (5) That in certain of these cases, where a rock, exceptionally rich in hornblende, had been partially fused by a pale colored granite, a banded black mica gneiss had been produced, indistinguishable, macroscopically and microscopically, from those which have been already mentioned.

It follows from these observations that the great group of crystalline rocks, which are connoted comprehensively as schists and gneisses, includes rocks which may have originated in one of three different ways: (1) Some have once been molten, but have become solid under rather exceptional circumstances, probably having lost heat slowly, and having continued to move very gradually during the process of consolidation. (2) Others have been produced by the thorough alteration of sedimentary materials, in which a high temperature has been maintained for a long time, in the presence of water and under considerable pressure. (3) Others, again, have been the result of great pressure, which has acted on rocks already crystalline, and has produced mineral changes, sometimes to the complete obliteration of the original structure. The second and third of these groups are truly metamorphic rocks; to the first the term, strictly speaking, is not applicable.

As a rule, it is not difficult to distinguish between these three groups, and in all probability the ambiguities which still remain will be solved by patient and persevering work. Cases, no doubt, will occur on which no inference can be founded; cases where, from one cause or another, nature's record has become illegible. But to this disappointment the scholar and the archæologist have to submit equally with the geologist. Negative evidence of this kind has no disturbing power; any amount of it is outweighed by a single scrap of clear and positive testimony. It is generally a waste of time to puzzle over bad specimens; they are much more likely to produce a perplexed agnosticism than a rational faith; for a creed has its place in science no less than in theology.

I have mentioned one mode in which materials rather markedly different in mineral character may be, in a certain sense, interstratified and to some extent blended, but should add that recent researches render it highly probable that there are other modes in which mineral or chemical constituents may be differentiated in a magma which was once homogeneous. To discuss these would carry us into questions of crystallogenesis, which have no direct bearing on my present subject, though in these also the microscope has rendered the most valuable services by suggesting inferences and by testing theoretical conclusions; questions upon which so much light has been thrown by the researches of Guthrie, Lagorio, Sorby, and others; but I may refer in passing to the law established by Soret, that by a change of temperature a homogeneous solution may be rendered heterogeneous; since any compounds by which it is nearly saturated tend to accumulate in the colder parts. Gravitation also, when certain minerals are crystallizine from a magma, may cause them to rise or

* It is probable that some changes of importance are produced in rocks by long-continued and repeated pressures, which are insufficient to give rise to crushing; but these I have passed by, because, as it seems to me, further evidence is needed before we can diagnose, with any certainty, the results of this particular disturbing cause.

to sink, and in this way also heterogeneity may be produced. So when the mass of mingled fluids and solids is constrained to move, a streaked or banded structure may be the result produced; as in a process familiar to the glass blower.

But when the geologist has learned from the microscope to recognize differences of structure in crystalline rocks, and to appreciate their significance, he finds that a wider problem is presented to his mind, provided he has not been led by the fascinations of laboratory studies to despise or neglect work in the field. Granted that one group of rocks, covered by the term metamorphic, has undergone great changes since its members were first deposited or soldified, can these be connected with any phase in the earth's history? Have they any chronological significance? Even twenty years since few geologists would have hesitated to reply: "None whatever; a rock may have undergone metamorphism at any epoch in the past. Muds and sands of Eocene, Jurassic, Carboniferous, Silurian, of any geological age, have been converted into crystalline schists. Proofs of some part of this assertion can be found even within the limits of the British Isles; it can be completely established within those of Europe." But during the last few years this hypothesis has been on its trial; witness after witness in its favor has been, so to say, brought into court, and has broken down under cross-examination. I can assert this without hesitation, for I have some personal knowledge of every notable instance in Europe which has been quoted in the debate. Microscopic study, combined with field work, has invariably discovered that some very important link in the supposed chain of proof is wanting, and has demonstrated without exception that these crystalline schists are very old; much more ancient always than any neighboring rock to which a date can be assigned, if not older than the first rocks in which any trace of life has been found. It has been also demonstrated that sedimentary masses, after they have been buried deep beneath superimposed strata and exposed to great pressure, have emerged comparatively unchanged. Such rocks are most valuable as illustrations of the effects of dynamical and other agencies; but they are sufficiently distinct from the crystalline schists to indicate that the environment in the one case must have differed greatly from that in the other. The results of contact metamorphism prove that heat is an important agent of change; but as these also present their own marked differences, they fail to afford a complete solution of the problem.

Moreover, among ordinary sedimentary rocks, we cannot fail to notice that, as a rule, the older the rock the greater the amount of mineral change in its constituents. A good illustration of this is afforded by the Huronian system of North America, the rocks of which are rather older than the Cambrian of this country. Some of them, while still retaining distinct indications of a sedimentary origin, have become partially crystalline, and supply examples of a transition from a normal sediment to a true crystalline schist. Even the older Paleozoic rocks almost invariably exhibit considerable mineral changes, though with them it is only on a microscopic scale. Hence, taking account of all these results, we seem to be forced to the conclusion that the environment necessary for changing an ordinary sediment into a crystalline schist existed generally only in the earliest ages, and but very rarely and locally, if ever, since Palæozoic time began.

Further, in regard to those peculiar structures which, as already stated, once led geologists to consider certain rocks, really of igneous origin, as metamorphosed sediments; they also appear to have been much more frequently produced in the earliest ages. They are common in association with the ordinary crystalline schists; they are found, so far as I know, rarely, if ever, with little altered sediments. The microscopic study of the coarser stratified rocks—grits, sandstones, etc.—lends some support to this view, by showing that, as we go back in time, a larger proportion of their materials, *cæteris paribus*, has been derived from crystalline rocks, and that even the fragments, obviously of sedimentary origin, exhibit signs of some mineral change; that is to say, the mudstones and sandstones in the later grits are apt to be represented in the earlier by phyllites and quartzites.

So the results of microscopic study, in alliance with, not divorced from, work in the field, lead us to the conclusion that in the early ages of this globe's history conditions generally prevailed which became gradually, perhaps even rapidly, rare and local; or, in other words, that in geology the uniformitarian doctrine must not be stated in terms wholly unlimited, though, since this was first enunciated by Lyell, nothing has been discovered to shake our faith in its general truth, or to resuscitate the catastrophic hypothesis which it replaced. But geologists are forbidden by students of physics to regard the universe as a "self-winding clock." The latter affirm, and the former frankly admit, that this globe through long ages has been losing heat by radiation; that there was a time when the temperature of its surface far exceeded that of molten iron—a temperature which now would be reached only at a depth of many miles. If this be so, the conditions under which rocks were formed on the surface of the globe in early days must have been very different from those which subsequently prevailed. Suppose, for example, this surface to have been just white hot—namely, at a temperature much below that at which most, if not all, lavas consolidate. In that case the ocean would be vapor, and the weight of the atmosphere would be augmented by that of a shell of water of the area of the globe, and two miles in thickness; or, in other words, the atmospheric pressure would be about 350 times its present amount. If so, even a lava flow would consolidate under a pressure equivalent to that of some 4,000 feet of average rock. But after the surface temperature had become low enough to permit the seas to be gathered together, and the atmospheric pressure had become normal; after rain and rivers, winds and waves, had commenced their work; after sediments, other than the "dust and ashes" of volcanoes, had begun to accumulate; still these at a short distance below the surface would find a very different environment from that which now exists. It has been proved by Lord Kelvin that at the end of about one twenty-fifth portion of the whole time which has elapsed since the first soldification of the earth's crust, the underground temperature must have risen at nearly six times its present rate. To reach a zone the general temperature of which is 212° F., it would now be necessary to descend, as a general rule, at least 8,200 feet, and probably rather more. But in those early days the crust would have been at this temperature at a depth of about 1,000 feet, and at 10,000 feet it would have risen to 1,050° F., instead of 250° F., which now would be exceptionally high. To this depth many rocks, both in Palæozoic and later ages, have been buried, and they have emerged practically unchanged. Hence it follows that the latter temperature is comparatively ineffective; the former, however, could not fail to facilitate mineral changes and the development of coarsely crystalline structures.

These changes, these structures, have been produced in sedimentary rocks in the immediate neighborhood of a large mass of intrusive igneous rock, such as a coarse granite. To what temperature the former have been raised cannot be ascertained. Suppose, however, it were 1,500° F., which probably is not a very erroneous estimate, this temperature, at the epoch mentioned, would be found at a depth of 15,000 feet. It is now, probably, at least 15 miles beneath the surface. In other words, the zone at which marked mineral changes could be readily produced, quickly sank, and has long since reached a depth practically unattainable. The subterranean laboratory still exists, but the way to it was virtually closed at a comparatively early period in the earth's history.

Another effect of this rapid downward increase of temperature must not be forgotten. When it amounted to 1° F. for every 10 feet of descent, a temperature of 2,000° F. would have been reached at a depth of not quite four miles. This would be rather above the melting point of many rocks, if they were at the surface; so that, even under the pressure, they would be either very near it or imperfectly solid. If the thickness of the crust were only about four miles, flexures would be readily produced, and the effects of tidal stresses would be considerable; but even if the earth had become solid as a whole, there would have been large masses of rock, comparatively near to the surface, in an unstable condition, and thus liable locally to slow deformations, displacements, fluxional movements, and intrusion into other masses already at a high temperature, with the result of partial melting down and mutual reactions. Disturbances such as these, slow, but constantly recurring, would produce structures imitative of stratification. It is a remarkable coincidence, to say the least, that these structures are characteristic of Archæan rocks, and are extremely rare, if ever present, in those of later date.

But some geologists are so rigidly unformitarian as to shrink from admitting that any portion of the earth's original crust can possibly be preserved. "Take time enough," they say, "and the changes can be made." But will the time alone suffice for every kind of change? How long will it be before gunpowder explodes at blood heat? But passing over this obvious difficulty, we may ask: Is there time enough? So geologists once thought, as fancy traveled back over endless æons. But they are checked by the physicist. "Earth and sun alike," he affirms, "are masses subject to the laws of radiation; these countless millions of years of which you dream will bring you to a period when not only the earth, but also the whole solar system, was nebulous. All the history of your planet, physical as well as vital, so far as it can be covered by your records, must be compressed into a very moderate number of millions of years, for we have to consider the possibilities not only of a cooling earth, but also of a cooling sun." If this be so, and it seems difficult to dispute the decision; if we are forbidden to look back along "the corridors of time" till they vanish in the perspective of infinite distances, it becomes more and more probable that the whole volume of the earth's history is within our reach, and that its opening chapters will some day be deciphered.

The progress which has been made since the microscope was pressed into the service of geology augurs well for the future, if we work in a spirit of skepticism and a spirit of hope. Of skepticism, lest we trust too much either in ourselves or in even the princes of science; for experience proves that the seductive charms of phantom hypothesis may lead all alike astray from the narrow path of truth into the morasses of error. Of hope, for experience also proves that by patient labor and cautious induction many an illusion has been dispelled and many a discovery been made. Our eyes must soon grow dim, our hands become nerveless, but other workers will be found to take warning from our mistakes and to profit by our toil. The veil which shrouds the face of nature may be never wholly withdrawn, but its fringe has been already raised; even in our own generation so much has been accomplished that the hope may be indulged of at last learning something of the history of these earliest ages, when the earth had but lately ceased to glow, and when the mystery of life began.

LORD DELAMERE'S LIONS.

As nearly akin to nature as the naturalist's art can make them, two lions—rampant—are being shown by Mr. Rowland Ward at his well-known "Jungle" in Piccadilly. They form part of a heavy bag which young Lord Delamere lately made during a sporting expedition into Somaliland, the sum total of his prowess consisting of fourteen lions, twenty-one gazelles, seven leopards, and a large collection of Somali birds. Most formidable of this group of captures are the two fighting lions which Mr. Ward has mounted with much fidelity. It will be news to many that the animals are not "stuffed," but actually modeled in a special composition after the manner of the sculptor's "mould," the skin being afterward affixed while the model is still plastic. In this particular instance the effect is eminently satisfactory, and the *coup d'œil* to the onlooker is realistic to a degree. Especially suggestive of breathing life are the cordlike veins and straining sinews of the struggling beasts, the more striking in effect, perhaps, if mentally contrasted with the caged lions at the "Zoo," whose muscular development is much less brawny than that of the forest-ranging brutes which fell to Lord Delamere's gun. One of the pair indeed is described as probably the finest ever brought to Europe. He took an unconscionable amount of killing, however. Though wounded in the shoulder, he contrived to retreat into dense cover, where he lay hidden until morning. Failing, even by the aid of fireworks, to draw him from his lair, Lord Delamere advanced to meet him at close quarters. Out rushed the "king of beasts," met by two shots from Lord Delamere's rifle, but without effect. Then the lion made his charge, but received a third shot, and fell dead almost at the hunter's feet.—*London Daily Graphic.*

A TROPHY OF SPORT FROM SOMALILAND.

USEFUL INSECTS.

WE frequently hear a great deal said about the constant struggle for life and the survival of the fittest, but many of those who discuss the subject think only of its bearing on human life, forgetting that the same influences are constantly at work among the animals, and even among the little creatures that live amid the plants and flowers, and have their own work to perform, a work of the greatest importance to man. A few of these useful insects are shown in the accompanying engraving, for which we are indebted to our excellent contemporary *Ueber Land und Meer.*

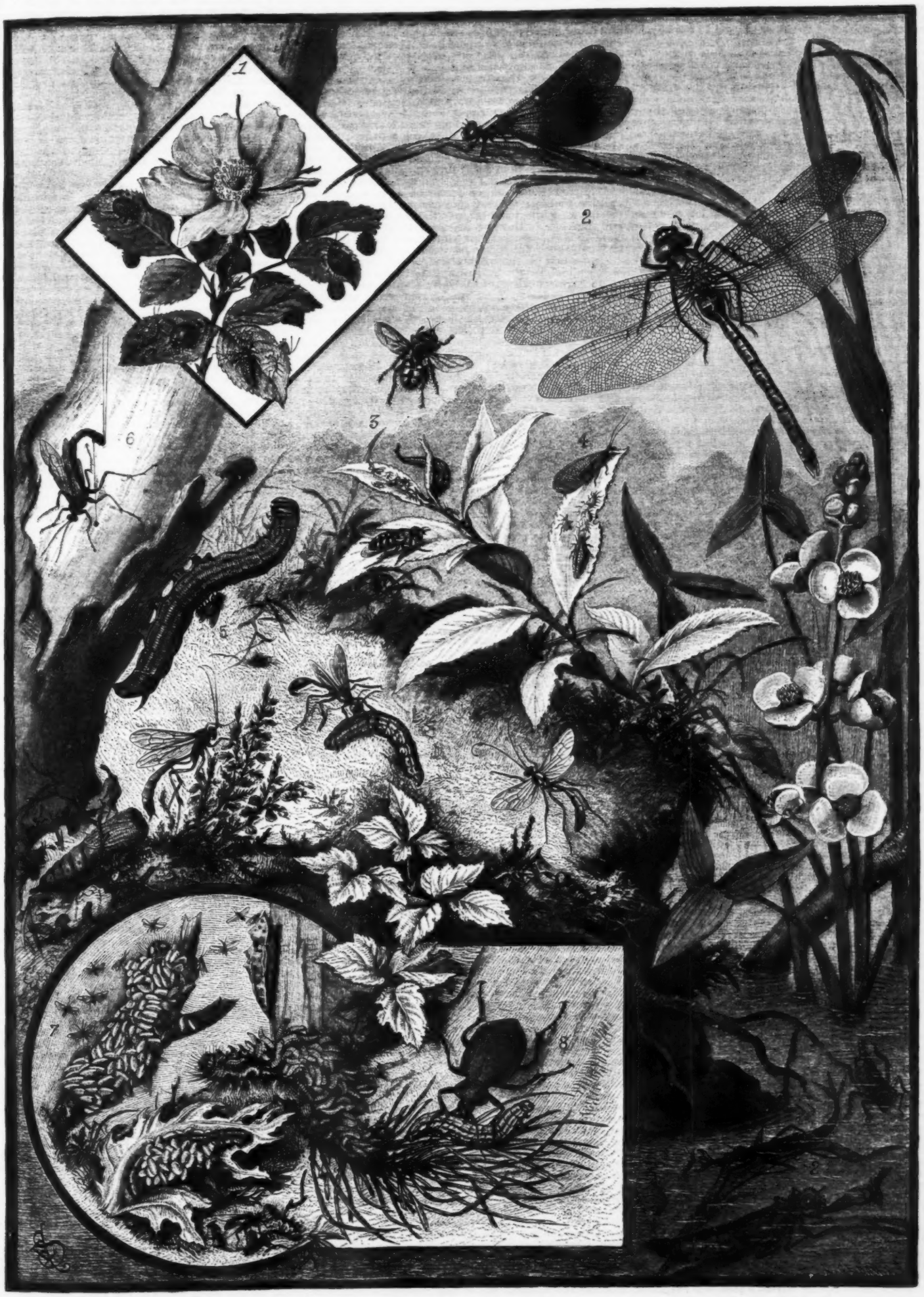
The best known of all those insects which may be designated as useful is the lady bird or lady bug (No. 1 in the illustration), a pretty little hemispherical beetle. It is very common everywhere, but, although so familiar in its perfect state, its larva is comparatively little known, in spite of the fact that when in this latter condition it does its most effective work in kill

ing plant lice, which are greedily devoured by the larva, an ugly-looking little grub, pointed at the rear, provided with numerous little knobs and prickers, and with six legs near the fore part of the body. Any one who watches its vigorous attacks on the lice on a rose bush will be convinced of its great usefulness, and will appreciate the fact that it is better to allow a pernicious insect to escape than to kill a useful one. One who cannot, with certainty, distinguish such larvæ from other similar worms should be careful not to tread, as so many do, on any worm without consideration.

The gauze-winged fly (Nos. 3 and 4) is as useful as the lady bird, but not as well known, although much more liable to be killed by men, for frequently a chance wind will catch great numbers of these flies and carry them into dwellings. Their appearance in large numbers is considered an evil omen by the superstitious, and even educated people are sometimes obstinate on this point. Many of the gauze-winged flies belong to the neuroptera; their larvæ are long and worm-like and extremely ugly in appearance. We do not prize them as they deserve until we understand that they are active destroyers of vermin.

Very few need any description of the Libelluladæ (No. 2), or, as they are commonly called, dragon flies or devil's needles. Wherever we wander by the water, be it river, lake, brook or pond, if there are not too many water birds, geese, ducks or swans, we find innumerable dragon flies moving about in their strange, quick way. Although so common, comparatively few know of their propensity for devouring Hessian flies, frit flies, and other grain-destroying insects. Their larvæ, which are as ugly as they are greedy, live under water, where they feed on other larvæ, of gnats and other creatures that are troublesome to man, and are also developing under water. Both the larvæ and the fly are greedy creatures, and it is on account of this greediness that they have been named "dragon flies."

There are other extremely useful insects which we



USEFUL INSECTS.

do not see as often as those of which we have been speaking, among them the ichneumon wasps and flies (Nos. 6 and 7). Very few realize their worth. Each female of the many species bores into a caterpillar or other larva—the flies of one species generally restrict themselves to certain caterpillars—and lays one or more eggs in its body. These eggs hatch and the larvæ which come from them live on the caterpillar, utterly destroying it. As they increase very rapidly, they limit the increase of other insects. The amount of destruction caused in woods, by caterpillars, would be enormous, and man would be powerless to stay it, except by cutting down or burning the woods, but nature comes to his aid and preserves the equilibrium; in a short time the caterpillars are killed and their destruction ceases "all of itself," as people say. Upon closer study these ichneumos flies are found to be very interesting creatures. The females of some species lay their eggs in those of other ichneumos flies, so that one parasite develops in another parasite. All good natural histories give us full accounts of them.

Among the most useful of all insects are the so-called caterpillar flies (No. 5), which are scarcely known, even to educated people. There are many species of them, although they are not as numerous as the ichneumos flies. They are useful because they are parasites, laying their eggs not in, but on the outside of, the bodies of caterpillars. If, when we are in the woods, we see gray, black, or yellowish flies buzzing noisily about in the grass, we should be careful not to destroy them, for their young are parasites that live on the most destructive caterpillars.

The engraving shows, of course, only a few of these destroyers, but others might be mentioned, such as the ant and carabid, including the ground beetle (No. 8), which live on caterpillars and larvæ of other noxious insects. It would be not only impossible, but also unnecessary, to attempt to represent them all, and therefore a few have been grouped in a single picture. Whoever feels inclined to investigate further the great number of insects that are more or less useful, can do so by the aid of the many good natural histories.

A LUMP OF CHALK AND ITS LESSONS.

By R. LYDEKKER, B.A. Cantab.

PROBABLY all Englishmen—certainly all those dwelling in the eastern and southeastern counties—are familiar with the pure white rock which we call, from the Latin *creta*, chalk. It is indeed this very familiarity which breeds the proverbial contempt, and causes us to take but scant or little notice of what is really a very beautiful substance in itself, altogether apart from the interest with which it is invested from a geological point of view. If chalk were very rare instead of being exceedingly abundant, there is little doubt that it would be reckoned as a beautiful substance, worthy to stand as the best example of a pure white mineral alongside of virgin sulphur as the finest sample of a yellow one. If, moreover, chalk had happened to have undergone the action of intense heat under equally intense pressure, it would assuredly have produced an even finer and purer statuary marble than that of Carrara, and might thus have been one of the most valuable of rocks.

A complaint may not unfrequently be heard among those more or less deeply interested in geological science who happen to dwell in a chalk district, that the very sameness of the chalk formation throughout England prevents them from finding any interest in the geology of their own districts, and thus leads them to regret that their lot had not been cast in regions where a variety of rocks are to be met with. Although there is a considerable amount of truth in this complaint, yet if rightly studied the chalk is so peculiar and unique a formation as rather to embarrass us with the number of considerations and problems to which it gives rise than to be deficient in interest.

Examining a lump of the pure white chalk of many parts of England, such as that of Dover, we find that it consists, both to the naked eye and under an ordinary lens, of an exceedingly fine-grained homogeneous soft substance, adhering strongly when applied to the tongue, and leaving a white streak when rubbed on other substances. If treated with vinegar, or any other acid, it will effervesce strongly, with the liberation of the gas commonly known as chokedamp, or carbonic acid, while the base unites with the new acid to form a fresh compound of lime. The lime may be obtained in a pure condition by burning the chalk, as in a lime kiln, when the carbonic acid is likewise given off; and we thus learn that chalk consists of carbonate of lime. As a rule, when we examine a chalk cliff we shall find that the chalk, although stained here and three with iron, is identical in structure throughout great thicknesses, and that it shows nowhere any signs of crystallization. Occasionally, however, as at Corfe Castle, near Swanage, in Dorsetshire, we shall find that the chalk has become so hard as to leave no distinct streak when rubbed lightly on other substances; while its cracks and fissures are filled with translucent crystals of white spar—the calcspar or calcite of mineralogists. Here then we have the chalk so hardened, probably by the effects of subterranean heat, as to form what is popularly called a limestone; while a farther step would have converted it into actual marble. The geologists would indeed apply the name limestone to chalk, ordinary limestone and marble indifferently; but since the popular usage is different, it is well to be assured that all three are but various modifications of one and the same substance. In the North of Ireland the basalt of the Giant's Causeway has converted the chalk still more completely into a hard limestone.

Chalk, then, may be defined as a fine-grained, white, non-crystalline, soft limestone. This, however, by no means exhausts the subject of its composition. Thus if we take a piece of chalk and wash it carefully in water with a hard brush so as to reduce it to a state of mud, and examine the portion which falls to the bottom of the vessel under a microscope, we shall find that this is very largely made up of various shell-like substances.

Many of these are minute fragments of what may have been real shells, while others are portions of the spines of sea urchins, and others, again, are the flinty spicules of sponges. By far the larger proportion consists, however, of perfect objects of extremely minute size, mainly belonging to that lovely group of animals known as foraminifers, or shortly, "forams." Of these beautiful little shells some are coiled in a manner recalling the shell of the nautilus, while others consist of globular masses arranged either in a coil or in a straight line, the globules gradually increasing in size from the summit to the mouth of the shell. In all cases, however, the walls of these shells are perforated by the inconceivably minute apertures from which the forams take their name, and through which, when alive, the creatures protruded delicate threads of the jelly-like protoplasm of which their soft parts are composed. Truly marvelous in beauty are these forams, although pages of description can give but a faint idea of them, and the student should see them for himself under a microscope. So numerous, moreover, are these forams and other equally minute organisms in the white chalk, that they frequently compose half its substance, while it is stated that in some rare cases they may even rise to as much as ninety per cent.

We have now, therefore, to add to our definition of chalk that it is largely composed of the shells of the minute animals known as forams, together with those of other allied creatures, and so may accordingly speak of it as a limestone which is evidently to a large extent of organic origin. Moreover, as these forams are more or less closely allied to species inhabiting the ocean at the present day, we should be justified from this evidence alone in regarding the chalk as a formation of marine origin. This origin is, however, equally well proved by the larger fossils, such as shells of sea urchins, scallops, oysters, etc., commonly occurring in the chalk; while, in addition to this, the extreme purity and thickness of the formation would of itself be sufficient to demonstrate that the chalk is the result of long-continued deposition on the bottom of the sea.

Thus much for the composition of our lump of chalk as examined in the laboratory, and we now turn, as all geologists worthy of the name should, to its occurrence in the field. If we look at one of the tall chalk cliffs of our southern coasts, as in the neighborhood of Dover, we shall be first of all struck with the extreme homogeneity and purity of the whole formation from top to bottom, through a thickness which in this neighborhood is close upon 1,000 feet and in Norfolk is more than 1,100 feet. This similarity of composition throughout such a vast thickness is totally unlike what we are accustomed to observe in other rock cliffs (although there is some approach to it in the blue mountain limestone of Derbyshire), where we generally find alternating bands composed of rocks differing both in color and structure from one another, and we are thereby led at once to conclude that there must be something very peculiar connected with the deposition of the chalk. How was it that in the old sea there were not only no currents bringing loads of sand or clay to alternate with the pure white limestone, but above all that there was not a tinge of coloring matter to stain the virgin purity of the newly-forming chalk during those ages and ages of time, while drifted logs and fruits occur but rarely?

A closer inspection of a large thickness of chalk will, however, reveal the fact that there is not a complete similarity in the nature of the rock throughout the entire formation. Thus, whereas in places where nearly the whole formation is displayed we find throughout the uppermost 400 feet layers and nodules of flint are thickly distributed throughout the mass, generally forming more or less well marked lines which indicate the original planes of the deposition of the rock, as we pass to a lower level the proportion of these flints becomes gradually less, till, after we have passed downward through some 130 ft., they finally disappear, and are wanting throughout the whole of the lower part of the series. Moreover, in this lower chalk, or chalk without flints, we shall find, as we pass downward, a gradual tendency to lose the pure white color of the upper chalk, and to assume a buff or grayish tint, while in the very lowest beds we shall not fail to notice the appearance of a number of small grains of a greenish colored mineral. If, again, we try to dissolve this lower chalk in acid, we shall find that as we descend in the series there is an ever-increasing quantity of an insoluble remnant, which would be shown by analysis to be of the nature of clay. Both these circumstances point to the conclusion that at the time the lower chalk was laid down the conditions were by no means so well adapted for the deposition of a pure carbonate of lime as was the case in the latter time of the upper chalk with flints. What these conditions were we shall consider subsequently, but we have now to direct our attention to the area over which the white chalk extends.

In the northwest the furthest limits to which the white chalk extended are found near Belfast, where, as we have said, the rock has been converted into a hard limestone by the action of heat. Although we do not again meet with chalk till we reach the east and south of England, where it forms large portions of our coast from Dorsetshire to Yorkshire, yet it is probable that the chalk sea embraced the foot of the Welsh Mountains, which formed an archipelago. From England the white chalk may be traced without any alteration in its character through the north of France, the south of Belgium, the eastern part of the Netherlands, and thence through Westphalia, Hanover, and Galicia, into Poland and Russia, where it reaches on the one side to the foot of the Urals and on the other to the Crimea; moreover, to the northward it occupies a considerable portion of Denmark and the southern extremity of Sweden. Although the white chalk is now only distributed over the surface of this region in larger or smaller patches, being sometimes covered up by newer (Tertiary) deposits, and in other places totally wanting, there is evidence that it once extended continuously over the whole. Moreover, the absence of any traces of the white chalk in the regions to the west and north of those mentioned indicates that the present limits of the chalk in those directions mark approximately the boundaries of this cretaceous sea; this sea being probably cut off from free communication with the Atlantic by a barrier connecting western France with Cornwall and Ireland and by another joining Scotland with Scandinavia.

The above area includes the whole of the white chalk; but when we trace this chalk southward into Bohemia and Saxony, we find that it has undergone a very remarkable change. Thus, although it contains the same fossils as to the northward, the rock itself, instead of being the pure white limestone to which we have been accustomed, consists of a series of massive sandstones about as unlike chalk as anything well could be. It is probable, indeed, that these cretaceous sandstones, as we may call them, were formed in a gulf on the southern coast of the white chalk sea, which was unfavorable to the deposition of chalk itself; and as these sandstones were undoubtedly deposited at the same time as the pure chalk, we thereby learn the very important geological lesson that similarity or dissimilarity in the mineralogical structure of a rock is a matter of very minor import indeed. We may illustrate this by reference to architecture. Thus, a Gothic church may be built either of sandstone, limestone, marble, or, for the matter of that, brick; but it will still be (exclusive of course of our so-called modern Gothic) absolutely characteristic of one particular period of European architecture. This Gothic style will be distinguished by certain peculiarities in the structure of its arches and pillars, as well as by the ornaments with which they are embellished. Just so in geology we have a chalk or cretaceous style, in which, although the rock itself may be either chalk, or sandstone, or limestone, or slate, yet its architectural details—that is to say, its fossils—will be the same, not only throughout Europe, but, within certain limitations of variation, over the whole world. This is one of the important lessons to be learned by a comprehensive study of our white chalk.

The second great lesson taught by the white chalk is, however, of perhaps still more importance. We have seen that the white chalk was deposited in a sea cut off from free communication with the Atlantic to the west and north; and the range of the Ardennes, which formed its shore in the southwest, together with the evidence of the near neighborhood of a coast afforded by the sandstones of Saxony and Bohemia, indicates that this sea was a *mare clausum* (in a geographical, not a political sense), somewhat like the Mediterranean or the Black Sea. Now, from the apparent similarity of chalk to the ooze forming in the abyssal depths of the Atlantic and the other large ocean basins, it was taught but a few years ago that the chalk itself was deposited in an ocean of similar depth. The *mare clausum* theory, however, is of itself a sufficient obstacle to the acceptance of such a view, since it is impossible to conceive that a sea of such small dimensions could ever have had depths at all approaching those of the Atlantic. The Atlantic theory, if we may so call it, of the chalk was, however, at once and forever dissipated by the researches carried on during the voyage of the Challenger. Those researches showed that the so-called abyssal deposits, instead of being very like the chalk, were really very different. Even the ooze has not the purity of the chalk; while the large areas of red clays covering the ocean basins have no analogy in the latter.

Moreover, it has been proved that the abyssal deposits are laid down at a rate of almost inconceivable slowness—so slowly indeed that even meteoric dust forms an appreciable portion of the red clays; while the earbones of whales and teeth of sharks that strew the ocean floor have lain there so long as to have become coated over with a thick layer of manganese precipitated from the water of the ocean. On the other hand, the remains of fishes and other delicate organisms which occur so beautifully preserved in the white chalk clearly indicate that its deposition must have been comparatively rapid, and must have taken place in a sea where there was abundance of mineral matter either in suspension or solution. Again, the fauna of the chalk, especially the sponges, is one such as would be found in comparatively shallow seas, and is quite unlike that of the Atlantic depths. Indeed, it is quite probable that the chalk sea may not have exceeded some one to two thousand feet in depth.

The great difficulty in regard to the chalk is, indeed, to explain its purity and the very rare occurrence of drifted materials found embedded in it. The *mare clausum*, with no tides and perhaps but few large rivers flowing into it, and its shores largely composed of hard crystalline rocks like those of Scandinavia and the Ardennes, will, however, to a certain extent remove this difficulty. Even then, however, it is doubtful how sufficient material for the formation of the chalk could have been obtained; and accordingly one of our most eminent living geologists suggests that, in addition to its partially organic origin, chalk may have been largely formed by a chemical precipitate of carbonate of lime.

Be this as it may, the degradation of chalk from its former position as a supposed typical abyssal deposit has taught the great lesson that almost all the stratified rocks with which we are acquainted were laid down in comparatively shallow water, and consequently has led to the general acceptance of the grand doctrine of the permanence of continents and ocean basins. By this, of course, it is not meant that the whole areas of several of our continents, such as Europe, have not been (as we know they have), many times over, beneath the sea. Indeed, what we have already said as to the extent of what we may call the cretaceous Mediterranean show sthat at a comparatively late period of geological history a large part of Central Europe was sea. Neither does this doctrine forbid such changes in the present configuration of the earth as would be implied by a land connection between Africa and Southern India. What, however, it does say, and that in the most emphatic manner, is that where continents now are, there deposits have always been going on, and there land, of larger or smaller extent and of ever-varying contour, has always been; while the great ocean basins, like those of the Atlantic and Pacific, have existed as such since the globe emerged from its primeval chaos. This, then, is the second great lesson taught by a lump of chalk!

We have, however, by no means yet exhausted the interest connected with the subject of chalk. In the first place, the gradually increasing marly character of the lower chalk points to a condition when the sea was much less deep than at the period of the white chalk. If, indeed, we go lower down in the rock series, we shall find the white character of the chalk has completely disappeared when we reach the underlying blue "gault" of Folkestone, which implies the existence of currents or rivers largely charged with mud. Still further back, we have the fresh water clays and sandstones of the Weald of Kent and Sussex; and we thus learn that at that period Southern England was

in the condition of a large delta, after which there was a gradual subsidence, culminating in the *mare clausum* of the period of the white chalk. Then, again, we have seen how the "architectural style" of a rock, as exemplified by its fossils, is the one all-important point connected with it; and the alteration of the English chalk into the cretaceous sandstones of Saxony ought to have prepared us for more extensive modifications of these rocks as we proceed to regions still more remote from where they are typically developed. If, then, we turn to a geological map of Europe, we shall find a large area of its southern half colored in, as being formed of cretaceous rocks—that is, rocks equivalent in point of age to the white chalk. The description or, still better, an actual examination of these rocks will show, however, that they have but little in common with the white chalk. They consist, indeed, of hard, compact, and often dark-colored limestones, containing many fossils identical with those of our own chalk, together with certain others of different types; thus showing that we have entered an area where the conditions of life were somewhat different from those obtaining in the *mare clausum* of the white chalk. From the center and south of France these cretaceous limestones may be traced across the Pyrenees into Spain, and so into North Africa, while eastward they extend across the Alps into Switzerland, Italy, Bulgaria, Roumania, and thence along the Mediterranean basin into Asia. That these rocks stretch far into the heart of Asia is now well known, and since rocks of somewhat similar type containing well-known European cretaceous fossils are found in the inner Himalayas, it seems highly probable that this southern cretaceous sea connected the Mediterranean with the Bay of Bengal. Whereas similar cretaceous fossils occur on the east coast of India, in the neighborhood of Madras, and since there are some very remarkable similarities between the fresh water rocks of the peninsula of India and those of South Africa, while many animals are now common to those two countries, there are very strong reasons for considering that peninsular India (which was then cut off from the rest of Asia by the cretaceous sea) had a land connection with the cape by way of Madagascar. We know indeed that this southern cretaceous sea communicated freely with the Atlantic, by what is now Spain and France, and we are thus led to conclude that there was formerly a direct sea communication between the Atlantic and the Bay of Bengal by way of central Asia. Europe and Asia then formed a northern continent separated by this cretaceous sea (of which the Mediterranean is the shrunken remnant) from a southern continent which included both Africa and India proper. Such is the wide interpretation given to the doctrine of the permanence of continents and ocean basins.

The study of the European chalk, besides the two great lessons to which we have especially directed attention, has, therefore, proved to us the former existence of two great seas, in which the cretaceous rocks were deposited—the northern one being a *mare clausum*, cut off from the Atlantic, in which was deposited the white chalk, while the southern one, in which the hard, massive limestones of Southern Europe were laid down, formed the connecting link between the Atlantic and the Indian Ocean, to which we have already alluded. We might pursue our subject further, and discuss the origin and nature of the flint and pyrites which are of such common occurrence in the chalk or we might direct attention to the more valuable and much rarer phosphates which are sometimes contained in it.

We might, again, discuss the peculiar characters of the cretaceous fauna, and show how that of the closed northern sea differed from that of the open southern ocean. We might do all this, and more; but what has been written is sufficient to show the amount of interest and the many weighty problems connected even with a "lump of chalk."—*Knowledge.*

A LAKE OF INK.

NEARLY all of the 3,500 Cocopah volcanoes in Arizona are situated near the east end of the volcanic area which they occupy. Several large mounds, once living volcanoes, are now quiet. Between the hills of lava, rock and *debris* are a large number of living, active volcanoes. From the sides of the hills, 50 to 200 feet above the surrounding waters, come forth most beautiful springs of clear, warm water, some so sour, others so sweet, so bitter and so strongly alkaline, that no living being or animal can drink it. These waters course down the hillsides, laying a coat of white, pink, purple, blue, or green, made by the mineral salts they contain, upon everything with which they come in contact.

In the midst of these hills is the Lake of Ink. There run into it scores of streams of clear mineral hot water, others that are warm, and two that are cold. The lake, one-fourth of a mile in length and one-eighth in width, lies like a gem set in these hills or these ancient volcanoes.

The hill is alive with volcanoes, even down to the very edge of the lake. At low water in Lake Pasqualitas it is divided from the Lake of Ink by a narrow ridge of hard, sulphurous clay thrown up by the volcanoes, which have assisted in making this bank. No less than sixty volcanoes—mad, spiteful, noisy little ones—line this ridge.

Here came the Indians for leagues and gathered the rich vermilion paint with which they decorated themselves in times of war in the ancient past, long, long ago. On the west the volcanoes stand as close together as they can be placed. For a space of a quarter of a mile by nearly one-half the tread of the lone footman rings the bell on the fragile crust till he stops through fear, balancing in his mind whether to advance or retreat, and while pondering as to what to do, the little "kicker," the liveliest, most wicked and spiteful of all the groups of volcanoes, besmears him with its boiling hot black mud.

The black ink-like water which fills the lake comes up to within three or four inches of the level of its shores. The temperature near the edge is about 110°, gradually growing warmer as you get down in it, and as you approach the center of the lake, on the surface, it is about 156°, and at a depth of 250 feet it is 216°. Near the shore on the east, south, and west sides the water is only four to six feet in depth for twenty feet or more into the lake, where the shelf breaks off perpendicularly, and there no bottom has ever been found. To the touch the water feels smooth and oily. The ashes and oil which cover the lake when its waters are quiet are from one-half an inch to an inch thick. The water of the lake is jet black, though it does not color the skin of those who bathe in it.

Under a glass the coloring matter seems to be a minute black substance held in suspension by the water, which adheres to white cloth immersed in the lake. To the taste the water is warm, salt, and bitter. To the bather the sensation on entering the water is grand, exhilarating to a wonderful degree, so much so that a bath of ten or fifteen minutes makes one feel as if he were under the influence of the very best brandy. Millions of bubbles, formed by escaping gases, keep the surface of the lake agitated at all times, till it rolls, boils, and foams as if ready to break over its banks and escape, and again only in myriads of sparkling globules, glittering in the sunlight. Whenever the volcanoes rage with anger the lake follows, and the sight of its maddened waters is well worth seeing.

From time immemorial these waters have been used by the different tribes of Indians, far and wide, at war and in peace, as the great all-healing remedy, following a bath in the hot mud of the peaceable volcanoes, for all fevers, rheumatism, scrofula, and venereal diseases. They take the invalid and bury him, all but his ears, eyes, and mouth, in the hot volcanic mud for from twenty to thirty minutes, then carry him covered with mud on a blanket the fifty or one hundred feet to the edge of the lake, and put him into the water, holding his head above it for from fifteen to twenty minutes. Then, rolling him in his blanket, they carry him a few feet away, to a shade which they have provided, and lay him on the hot sulphurous sand or rock, and there let him sweat. They repeat this in the afternoon.

At night they remove him to a place where the ground is not so warm, and let him sleep, and, if possible, where he can breathe the gases or vapors of the neighboring volcanoes. The cures wrought are perfectly wonderful, and could not be believed if not seen. A few white men have been there and tried the remedies, and thus far without a single failure. The Indians also drink the hot water from some of the springs, but not from all. Whenever they approach this strange, weird scene, this barren waste, even when they come on their trips for salt, which lies in great beds a mile or so beyond, they stop on the highest mound, and, with one hand shading the eyes, they screech and cry with that yell of "tra, tra, la, la, hoop, ya, lip, lip, soo, oo, oo, la," which makes your blood run a little faster in its channels, and then they wait to see if the gods of the desert are there to assist them.

If all is still, with naught but the half-smothered groans, mutterings, and underground heavings of these mysteries of "wonderland," they turn sadly away, to come again some other time. But if, after the third wild shriek or cry of theirs, old Monarch or some of his consorts answer with a volume of mud thrown high in air as a salute, then the Indians rush for their regal baths of mud, more than contented that the desert gods will hear and answer their wild man's prayer.—*Philadelphia Telegraph.*

PRESERVED GINGER.

THE marked difference between the Chinese preserved ginger and that from the West Indies has been the subject of inquiry by the authorities at Kew as to whether both articles are really the product of the true ginger plant (*Zingiber officinale*). The evidence—other than that of the root—pointed at one time to the fact that the same plant yielded both commercial articles; subsequent materials, however, indicated that Chinese preserved ginger was the rhizome of *Alpinia Galanga*, while that from the West Indies was from the original *Zingiber officinale*. It would seem, however, that still further research into the matter has restored the origin of Chinese ginger to the same plant as the West Indian.

Of the practice of ginger cultivation and the process of preserving, but little is generally known. As ginger is, however, an important article of commerce, both in its dried and preserved conditions, the following notes on the subject from the December number of the *Bulletin of the Botanical Department of Jamaica* may be of interest. The most suitable soil for ginger culture is said to be a well drained clayey loam. The land should be well dug and cleared of weeds. Small pieces or protuberances of the root, one or two inches long, are planted during March or April, four inches deep and nine to twelve inches apart. It is well to cover the land with a moulding of dead leaves, weeds, straw or litter mixed with manure. In a few months the whole ground will be covered. The flowers appear in September. When the stalks wither in the following January or February, it is time to dig up the roots. When the tubers have arrived at maturity and have put forth stems they are fibrous, but before this takes place, while they are still succulent and the young stalks are not more than five or six inches long, they should be taken up for preserving. Ginger is an exhaustive crop on the soil, and should not be planted in the same ground two consecutive years. The yield per acre is said to be 4,000 lb. and upward.

Black ginger of commerce is prepared by washing the root in water, boiling for a quarter of an hour, and then drying in the sun. White ginger, a much superior article, is prepared from the best and soundest roots, by scraping off the outer dark colored part, and then carefully drying without boiling.

Preserved ginger is made from the young tubers, which are scalded, washed in cold water, and then peeled; the roots are then covered with a weak sirup, and left for two days. The sirup is then poured off and replaced by a stronger sirup, and this is repeated two or three times until the sirup is thick and the ginger bright and nearly transparent. The following is given as the best method of preparing preserved ginger. Pour boiling water on your ginger, and let it steep for a day and a night, then peel and pare away all discolored and hard parts. Boil a sirup of 1 lb. lump sugar to six pints of water (this is for 12 lb. of ginger). Put your ginger into a stone jar and pour the thin boiling sirup on it, let this stand for a week or ten days, then draw off the sirup and throw another, exactly the same as the last, again boiling, over your ginger; let this stand for another week, then throw off the second sirup and drain the ginger well on a hair sieve, return it to the jar, and pour over it the final sirup, made as follows: 12 lb. loaf sugar to 12 pints boiling water; stir till the sugar is dissolved, for fear it should settle and burn, then boil till it is as thick as good honey, and drops slowly from a silver spoon; now pour boiling water over the ginger and let it stand till cold, when you can put it into the bottles or jars in which it is to remain. Put in the pieces of ginger, first, as close as they will pack, then fill right up to the cork, to leave no room for air. The corks should be new and good, not old ones that have been pierced by corkscrews.

Since the above was written, some instructions, similar to the foregoing, on the cultivation and curing of Jamaica ginger, printed for distribution in Trinidad, have appeared in the *Kew Bulletin* for April last, together with a notice of a sample of ginger recently received at Kew from Fiji, where it had been grown and cured, and the reports from experts in London were such as to induce further efforts in Fiji. It is described as "remarkable for its exceedingly fine aroma and peculiar pleasant taste, recalling that of lemon."

On the subject of the cost of preserving ginger and some of the Jamaica fruits for the English market, a correspondent of the Botanical Department, who, it is said, has been most successful in the operation, writes thus: "The price charged for all Jamaica preserves is excessive, and defeats its own ends. For instance, preserved ginger, say one shilling for the young ginger, to make 12 lb., one shilling for the first sirup, and for second, allowing sixpence per lb. for lump preserve sugar, the cost of this being 10s. 9d. per cwt. in England; sixpence for the last sirup. In fact, 6d. per lb. would more than cover the cost of production, apart from labor, and the labor is certainly not greater than that bestowed on most English preserves sold at from 4d. to 6d. per lb. The usual statement as to the cost of the manufacture of ginger is as follows: It takes 3 lb. of lump sugar at 9d. per lb. to make 1 lb. of ginger. Ginger has to be so much pared away that a shilling's worth makes only a few lb. The labor is very great, and the profit very small. All these are, I maintain, false statements, and have stood in the way of anything like a large and remunerative trade in Jamaica preserves being established. Fortnum and Mason give it as their opinion that the bar to such a trade is that Jamaica preserve cannot be sold in London in one shilling glass jars; the British public will buy a small jar of any foreign delicacy at 1s., when they would refuse a larger one at 1s. 6d. This seems a hint worth taking. We ought to popularize our beautiful and delicious preserves by selling them at a small profit, which experience has found again and again results in a much larger gain in the long run. For instance, can any Jamaican assert that guava jelly costs more to make than the best strawberry jam, which is sold in highly ornamental glass jars at 6d. per pound anywhere in England? The guavas grow wild here, and can be had in profusion for the picking. Jamaican vacuum pan sugar makes the jelly in perfection, and can be bought by the bunch at about 2½d. per lb., if I am not mistaken; and, having made both strawberry jam and guava jelly myself, I can confidently assert that the latter is not half the trouble of the former. My sole object in writing this is that I believe Jamaica is throwing away a large and lucrative trade, which might be hers, if she would remember her own wise saw, 'Greedy choke puppy.'"

These plain words may draw attention to this important subject, not only in the West Indies, but in other tropical countries.—*Jour. of the Society of Arts.*

PERIOD OF FORMATION OF THE FLOWER.

SEVERAL interesting observations on this subject have lately been recorded. W. Russell (*Rev. Gen. de Botanique*, 1892, p. 18) states that the male catkins of the walnut begin to be formed about the end of April, and are fairly developed by the July preceding their blossoming. The female flowers, on the other hand, make their appearance on twigs which are formed in the spring, and the whole of their development takes place in the same year. They are, therefore, fertilized by the pollen of male flowers formed at a very much earlier period. By July the catkin is about a centimeter in length, and the pollen sacs are then already formed, although the pollen grains are not fully differentiated until the moment of flowering. According to Sig. Martelli (*Bull. Soc. Bot. Ital.*, 1892, p. 52), there are two important periods in the development of the inflorescence of the vine, viz., the summer (about August), when the axial parts of the inflorescence are first formed, and the early spring (after February), when the differentiation is effected of the principal axis into secondary axes and flower buds. Winter is a period of rest, when there is no apparent increase in the buds. An examination in the autumn of the degree of development of the third and fourth buds from the apex of the branch will indicate the prospects of a crop of grapes for the ensuing summer. The yellow rays of the solar spectrum are those which take the greatest share in the decomposition of carbon dioxide and the process of assimilation; the blue are those which chiefly effect the movements of stimulation and of irritation; while the ultra-violet are most efficacious in the production of the flowers and reproductive organs. For the vine, salts of potash in the soil are of great importance. Professor Sach's theory that the substances which go to the formation of the flower are already formed in the green leaves receives support from a fresh series of experiments carried out by him in the case of the buds formed on the leaves of *begonia* (*Flora*, 1892, p. 1). Leaves of a *begonia* gathered at the end of May were propagated in the ordinary way on wet sand. Numerous buds were formed in the course of a few weeks; but it was only after they had grown to vigorous plants about the end of November that inflorescences were first produced in the axils of later leaves. Another series of leaves gathered from flowering plants at the end of July was propagated in the same way, and the buds formed on these already contained inflorescences in the axils of the first leaves, which blossomed in October, and which must have been present in a rudimentary condition in the very youngest condition of the bud. The conclusion drawn from these facts is that the substances which are used up in the formation of the flowers are present in the leaves in the summer, but not in the early spring.

EGYPTIAN SKETCHES.

By STANLEY J. WEYMAN, author of "Francis Cludde," etc.

ON THE NILE.

COLUMN FROM PHILÆ.

THE biographer is exposed to the constant temptation to over-rate the importance of his subject. But to over-rate the part which the Nile plays in the economy of Egypt is impossible. Egypt is, indeed, nothing more than the valley of the Nile. The Nile created it, the Nile fertilizes it, the Nile is its one great thoroughfare, the easy means of communication between Damietta in the extreme north and Assouan in the extreme south. A single fact is sufficient to demonstrate the importance of the river. Egypt does not contain one town of any size—with the doubtful exception of Alexandria, and that is connected with the Nile by several canals, if not by a natural channel—which does not stand upon its banks. Nor is the traveler likely to overlook the river as he moves about investigating the country. He will rarely find himself ten miles from his banks. He will constantly use it as a means of transport. He will probably have it under his eyes every day, and become familiar with it under all its varying aspects.

There may be some who still labor under a delusion which once possessed the writer; who still picture the Nile as a limpid stream flowing gently seaward between banks fringed with bulrushes and the feathery stems of the papyrus, while the lotus and the giant lily are borne upon its broad bosom, and the crocodile and the hippopotamus sport in its depths. If so, let them divest themselves at once of this pleasant illusion. The ancient river does not answer to this description. In the first place, Egypt does not now contain, if the prevailing opinion be correct, a single stem of the once famous papyrus which the old Egyptians used as writing paper, and the enduring qualities of which have been sufficiently proved by the survival of thousands of manuscripts to this day. The plant became extinct there many centuries ago, and those who would still see it growing wild must visit Syracuse, in Sicily, where it lingers in a branch, I believe, of the little river Anapo. As for the lotus, the other sacred plant of the Egyptians, which symbolized the northern part of the country as the papyrus did the southern, strange to say it never grew in the Nile. It was cultivated in ponds and reservoirs, probably in the sacred lakes attached to the temples; and in some pools, principally in the Delta, it is still to be found. Some bulrushes and a few lilies may possibly be discovered in the Nile, but not in parts frequented by the ordinary traveler; and it may safely be said that scarcely a river in the world is so poor in water plants, beautiful or luxuriant, as the river of Egypt. The annual rise and fall of the water render their existence in the stream itself all but impossible.

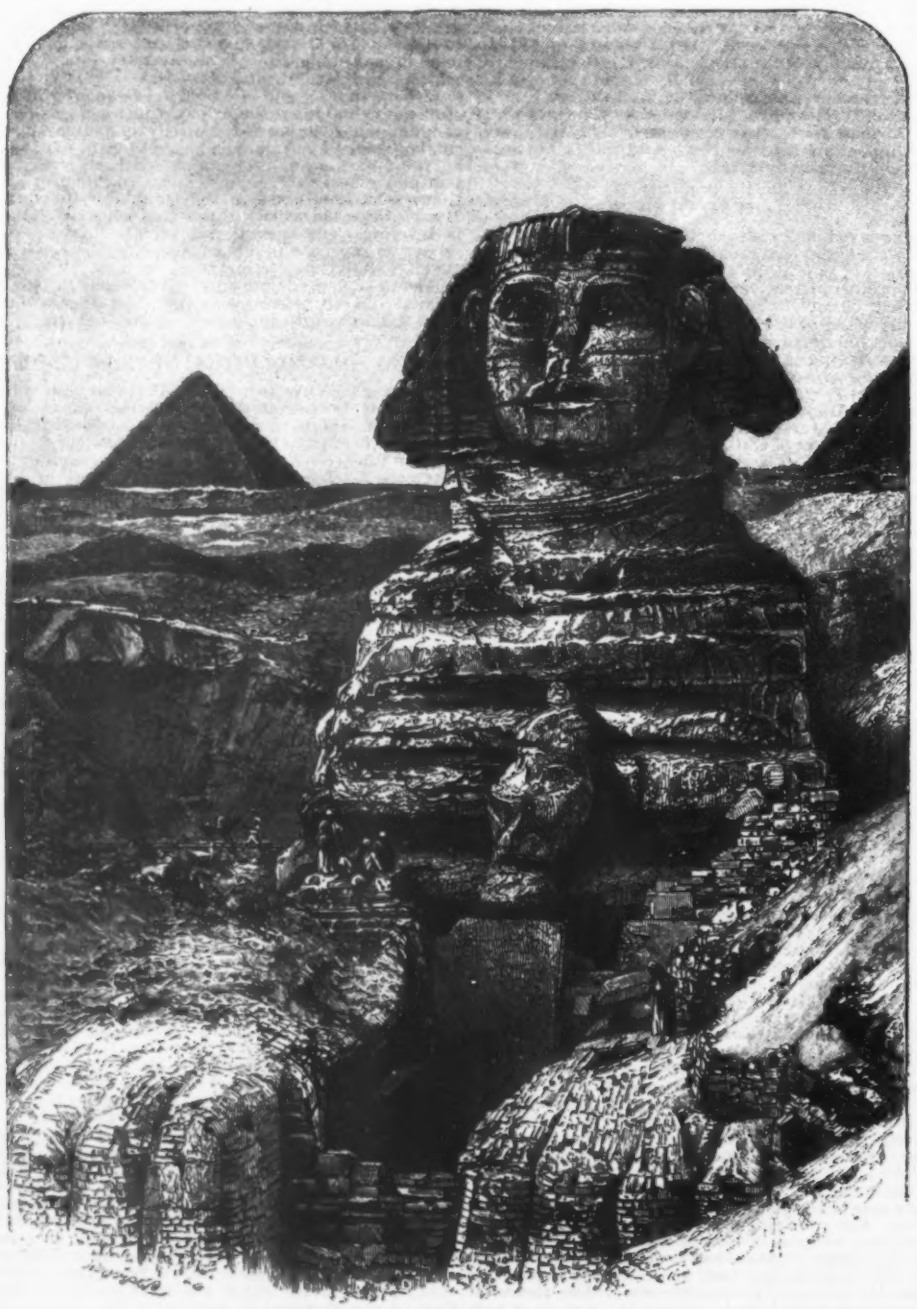
As for the crocodile and the hippopotamus, to mention them in Egypt raises a smile. A score of the former may still disport themselves, despite the march of progress and the paddles and screws of the steamboats, in obscure corners toward the southern frontier. But the hippopotamus is as completely extinct in the Egyptian Nile as in the Thames or the Tyne.

The water of the Nile, owing to the large amount of mud in suspension in it, is of a deep brown color. So much so, that if let into a bath to a depth of five or six inches, it renders the white bottom of the bath invisible, and soon deposits a sediment of appreciable thickness. Yet it seems to be drunk, even in an unfiltered state, with impunity. M. Maspero, one of the highest authorities on Egyptian antiquities, says that for a few days or hours after the river begins to rise in June the water is green and emits an evil smell, and that at a later period of the inundation it turns crimson or red, also for a few hours only. But owing to the fact that these phenomena occur in the hot season, the visitor is not apt to become familiar with them.

Apart indeed from its annual rise and fall and its connection with the history—always fascinating—of the country, the Nile is in itself an uninteresting river. It disappoints the traveler who comes to it looking for grandeur of scenery or diversity of landscape. It runs for a great part of its course between mud banks varying in height with the period of the year, but generally uniform and monotonous. Here and there the cliffs, which border the valley, close in and approach the stream on one side or the other, imparting a momentary picturesqueness to the scenery. But the bluffs and headlands soon fall away again, and even the effects they produce are but mediocre, or appear so to spectators acquainted with the Rhine or the Danube. Elsewhere the surroundings are tame, and it is not uncommon to hear the river compared to a great canal.

It contains few eatable fish, and those unsightly and tasteless. But in bird life it is very rich. The Nile valley is indeed the great bird road running north and south. The heron fishes in every shallow. The ibis haunts the banks. The pelicans stand in rows at the time of the inundation. Eagles, kites, ospreys, are common. On every sand bank black, or black and white, vultures hop about the carcass, and flap their outspread draggled wings. A kingfisher, more common and more soberly clad than ours, performs wonderful feats of diving within a few paces of the onlooker. The hoopoe, a remarkable bird about the size of a thrush, but grotesquely colored, orange, black, and white, with a comical crest of feathers on its head, flits from post to post along the bank. The little sand snipe and the true snipe prevail, and the quail visits the country in immense numbers in the spring. Owls haunt the palm trees and the ruins, and pigeons, which are reared in every village for the sake of the manure, are probably more numerous than in any other country in the world. But ducks and geese are now seldom seen on the river, and when seen are very shy. In these days of steamers, they prefer distant pools and marshes on the edge of the desert to the much-traveled, much-perturbed Nile.

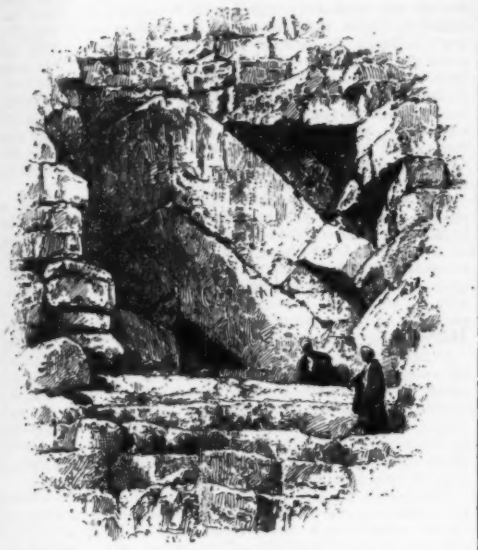
With this exception it is delightful to note the tameness of the birds in Egypt. They enter rooms and houses through windows or crevices left for ventilation, and once inside hop fearlessly about the floors, picking up stray crumbs. I have seen—and the sight was a pretty one—a sparrow perched on the corner of a table during the progress of a crowded hotel repast, and it is not uncommon to see them flitting across the ceilings of drawing rooms at Luxor. They do no harm, and are a source of pleasure to many; to none more than to those who have noted with regret the scarcity of wild birds in Italy, and have witnessed with disgust at Amalfi or Sorrento the elaborate stalking of a sparrow—a mere bundle of feathers—by half a dozen sportsmen arrayed in gaiters, Tyrolese hats, and carrying gigantic game bags. In Egypt they manage these things better. All birds, from the largest to the smallest, go unmolested, unless they are definitely useful for food. The great brown kite sits fearlessly on the roofs of Cairo hard by his cousin the crow, which is not black like our crow, but is black and gray, and might easily be mistaken for a pigeon. Every garden—at any rate in Upper Egypt—has its owl frequenting a tall palm tree, and hooting or whistling as nature guides it. Only when the crops are yellow for harvest, the slinger mounts a pillar at the corner of a field and pro-



THE SPHINX AND THE PYRAMIDS.

tects them from ravages which might otherwise be serious. Even then I think the pigeons are the greatest depredators.

When the Nile attains its extreme height, which is generally about September, the country presents a curious spectacle. It becomes a great lake. From the desert borders on one side to the desert borders on the other the flood extends. The pyramids of Gizeh, those great pyramids which usually stand six or seven miles from the river, cast their gigantic reflections far over the placid waters which lip the sand at their base. The villages, which invariably stand on elevated spots of ground, are isolated one from the other, and surrounded by their palm groves look like the coral



ENTRANCE TO THE GREAT PYRAMID.

islands of the Pacific. The suburbs of the towns even are flooded, and only a few embanked roads still rise above the surface. Almost all communication has to be carried on by means of boats. For awhile the tilling of the soil, the labors of shadoof and sakiyeh, are at an end; and the fellah, gathering his stock about him, waits in thankfulness for the departure of the waters and the reappearance of the soil, invigorated and fertilized by the mud, the annual gift of the river. Dwellers in the north have no conception how quickly and with what exuberance that soil, freed from the water and exposed to the fervor of an African sun, responds to the call made upon it. Last week it lay a mass of dark, chocolate mud. To-day the wheat shoots upward from it, and viewed from a distance it grows green already.

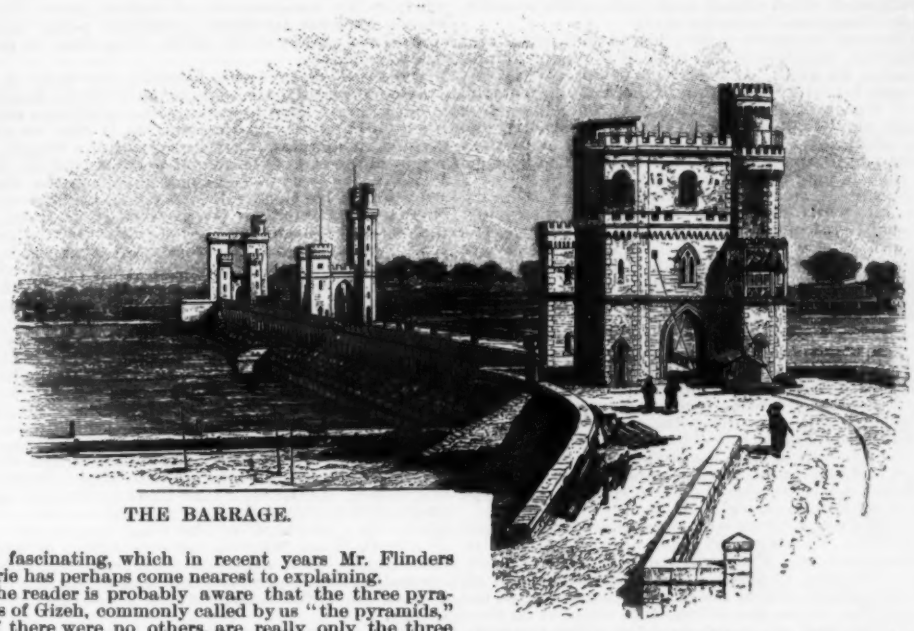
The common boat of the Nile is called a felucca. With its short mast and long boom, and huge white, wing-like sails, it is one of the most graceful boats to be seen; and contrives, as it glides up stream before the prevailing north wind, to add a beauty to even the longest and dullest stretches of the river. It carries chopped straw—the ordinary native fodder—down to Cairo; or it is to be seen dropping slowly down the stream high-heaped with earthen "goulahs," water pots, which are made in great quantities at Bellianah and other places in Upper Egypt. Or the cargoes are of wheat or beans or dates. Once, and not very long ago either, these boats carried slaves, but that is at an end now. At an end, too, unfortunately is the large traffic which formerly found its way down the Nile from the Soudan in the shape of gum arabic and the like. It is to be hoped that the time will soon come when this source of wealth to Egypt and the Soudan, and of enlightenment to the latter, will again be allowed to flow.

But it is not only between the north and the south,

TOMBS AT BENI-HASSAN.

between the Soudan and the Mediterranean, that the Nile affords easy communication. It connects, too, the Orient, the Red Sea, Arabia, and Persia, with the Mediterranean coast, though not, of course, directly. The gap between the Red Sea and the Nile is overcome by caravans, which cross the desert from the Red Sea port of Kosseir, and strike the Nile about four hundred miles above Cairo; either, that is, at Kenah, Koos, or Koptos. This is a very old trade route. The ancient Egyptian kings built forts to protect the journey across the desert. In their days the favorite point on the Nile was Koos. Later Koptos gained favor, and now Kenah derives all the advantages of this trade. The three places, however, are close together, and the road to them is practically the same.

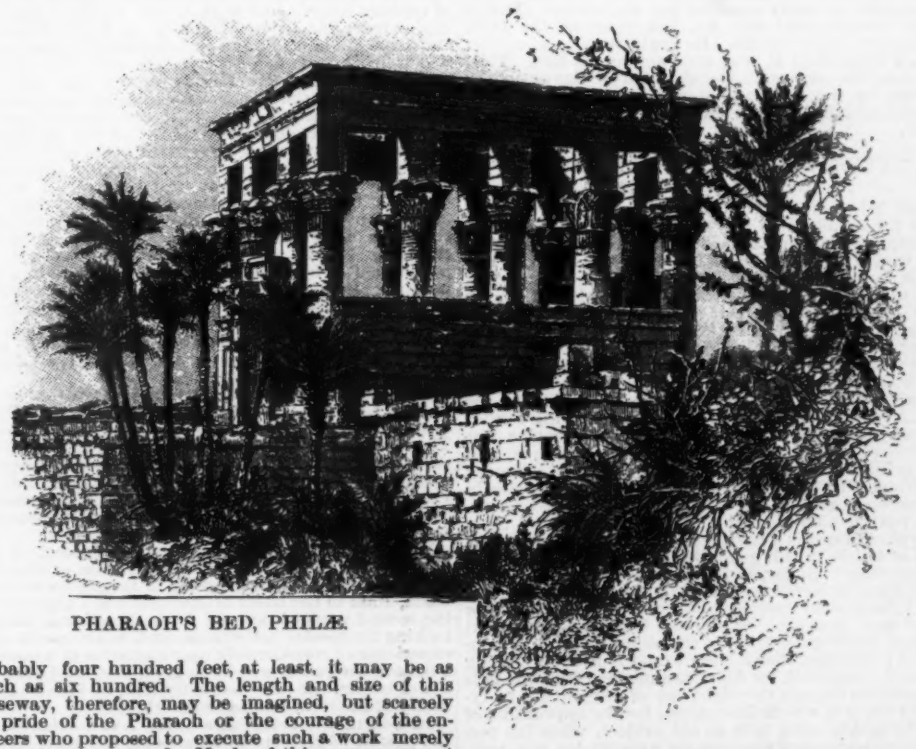
The Nile is, indeed, one of the oldest routes in the world. It was the thoroughfare along which, in the earliest ages of which secular history tells us anything, a great part of the materials used in building the pyramids was conveyed. Two, at least, of the three pyramids of Gizeh, though constructed in the main of limestone procured in the vicinity, were faced with granite brought from Assouan—called by the Greeks Syene, and hence our word Syenite. As Assouan is about six hundred miles from Gizeh, the labor of transporting these great blocks may be imagined. How they were removed from the quarries to the barges, how they were disembarked—some of them weigh upward of fifty tons—how they were carried from the place of disembarkation to the site selected, a distance this last of six or seven miles, are all mysteries to us, mysteries strange



THE BARRAGE.

and fascinating, which in recent years Mr. Flinders Petrie has perhaps come nearest to explaining.

The reader is probably aware that the three pyramids of Gizeh, commonly called by us "the pyramids," as if there were no others, are really only the three most prominent, the three in best preservation; and that on the same desert plateau, which stretches for many miles north and south of the site of the ancient city of Memphis, are scattered some sixty or seventy others, a few it may be older, and presenting for solution problems as obscure. Of these the pyramid of Abou Roash, which is situate about six miles north of those of Gizeh, is not the least interesting, and deserves, at least, a word of notice. It is not remarkable in itself, for little but the foundations and certain rock-cut chambers are left, and many savants are of opinion that it was never finished; but it is remarkable because it stands on a hill of some height, to the top of which the materials were laboriously dragged along a sloping causeway constructed for the purpose. There was a sloping causeway up to the Great Pyramid at Gizeh, parts of which are still visible. That pyramid, however, was not built on a hill, but only on a slight elevation, whereas the base of the pyramid of Abou Roash stands several hundred feet above the river;



PHARAOH'S BED, PHILÆ.

probably four hundred feet, at least, it may be as much as six hundred. The length and size of this causeway, therefore, may be imagined, but scarcely the pride of the Pharaoh or the courage of the engineers who proposed to execute such a work merely as a means to an end. Much of this causeway, not distinguishable at the first glance from a natural spur of the hill, still remains, and deserves more attention at the hands of engineers interested in the antiquities of Egypt than it has apparently received. On and about the upper part of it lie huge masses and innumerable broken fragments of granite, the granite of distant Assouan, brought hither by the river; the whole scene, with the stupendous causeway still running straight as an arrow from plain to hilltop, reminding the stranger of those tales of Cyclopean workshops which found credence with the ancients on the evidence of just such remains as these.

The pyramids, though the largest, are far from being the only tombs on the Nile banks. Egypt has, indeed, been called the land of tombs. Wherever cliffs of any height border the river they are honeycombed with graves—with rows upon rows of sepulchers cut into the solid rock, and for the most part long ago rifled. From the deck of a boat passing along this part of the river the eye roves over hundreds of dark openings cut in the face of the cliff, sometimes mere holes scooped out horizontally, sometimes the square doorways of a long series of connected vaults. The tombs of Beni-hassan, from the pillared entrances of which an unrivaled view of the Nile valley can be obtained, are peculiarly interesting, both as dating from the twelfth dynasty, about 2500 B. C., and as containing some columns closely resembling in style the fluted Doric pattern which had vogue in Greece nearly twenty centuries later, and of which Pæstum, near Naples, presents very fine examples.

From the time of Joseph, nay, from an age long anterior to the time of Joseph, who was probably prime minister and ruler of Egypt under one of the shepherd kings a little before the rise of the eighteenth dynasty, the country has been periodically visited by famines. All growth depends upon the annual inundation, and the annual inundation depends upon the fall of rain in and about the Abyssinian mountains, in the neighborhood of which the Blue Nile rises. As a rule the rainfall and the consequent height of the water vary little. But the rain may fail, or it may fall in excess. In either case Egypt suffers; in the one event from drought, in the other from floods which inundate the villages, and in the Delta in particular occasion immense damage, besides occupying the soil so long that a seed time and harvest pass by before the husbandman can get to his tillage. Accordingly the government has lately taken it in hand once for all to diminish these risks as far as possible by a permanent work. It has constructed what is known in Egypt as the "Barrage."

It is situate on the river at a little distance below Cairo, and consists, in plain terms, of a stupendous dam with flood gates in proportion, so constructed as to control in some degree the rise and fall of the river, espe-

cially as this affects the Delta. The work was begun and, in a sense, finished before the English interfered in Egyptian affairs; but it was finished so hastily and so carelessly, to say the least, that it was found to be practically useless. Later Sir Colin Moncrieff took it in hand, and under his care it has been reconstructed. As yet it has not been fully tested, but during the present year great results are expected from it. Gigantic as the works are—they are considered one of the sights of modern Egypt—they are not of course intended to supersede the natural rise and fall of the river, but only to regulate and control these operations in some degree; to store water when necessary, to economize the flood when the rainfall in Abyssinia has proved deficient, or to pass the water away as quickly as possible when the rise is abnormal. The works are in charge of the irrigation department of the government, one of the most useful official bodies in the world, the operations of which extend to all parts of the country, and are the cause of unmixed good.

Following the course of the river upward from Cairo to Assouan, the traveler will note little change in its character, its width, or the speed of its current. At Assouan, however, at the foot of the first cataract, the whole aspect of the Nile changes. There the river widens almost into a lake, the current slackens its pace, and instead of unending and monotonous mud banks, picturesque rocks of granite blackened by time and the action of the water fringe the shores. Gayly painted boats traverse the broad expanse in every direction, while hills bestrewn with bowlders and clothed in verdure rise into airy peaks, and form the background of a scene which smacks of the breezy freshness of the Scotch highlands. Assouan is indeed in natural situation the Queen of the Nile. The cataract, a series of rapids, not a fall, lies about three miles above it, the course of the river up to that point presenting a succession of charming prospects. Above the rapids, and about five miles from Assouan, lies the lovely island of Philæ, smiling with fertility and decked with the ruins of temples, which happily combine something of Greek grace—they are chiefly of late Ptolemaic origin—with Egyptian grandeur. There on the borders of Nubia, in the heat of a southern sun, the old worship of Isis lingered latest, and had its priests and priestesses, its ritual and altars, long after Christianity had become the state religion of Egypt and of the Roman empire.

Viewed from a distance, these temples are fair and lovely still. They stand in a spot beautiful almost beyond comparison. Time and nature have dealt tenderly with them, clothing them with flowers and all beautiful plants, hiding the rents in their sides and the havoc which fierce hands long since wrought on their walls. But land, go nearer, cross the silent precincts, walk through the crumbling halls, and the vaults and chambers given up to bats and owls, and not physical decay and noisomeness alone will thrust themselves upon your notice; but a score of things, before, behind, on either side, will point with no uncertain or wavering finger to a moral decay and degradation existing in those who once officiated and worshiped here, which prove, if any proof were needed, that Egypt's ancient faith did not die before its time, and that, dying, it left the world purer and more wholesome.

And perhaps the proof is needed. Time and distance cast a peculiar glamor, as of the setting sun, over the last days of a dying faith. For many the past, and particularly a great past, has itself a charm. There is romance in the final stand of a party, however mistaken and benighted. We all feel this, we all acknowledge it. The more kindly and generous our natures, the more readily we respond to such a claim.

But the claim is baseless, or rather it is founded only on certain instincts more or less chivalrous. For in truth, though good men die, the cause or the faith that is good does not die. Its death is its own conviction, a proof that it was not worthy to live. That this was the case with the old faith of Egypt can be proved by the evidence of any one of the score of temples which still look out upon the Nile.—*Leisure Hour.*

TURPENTINE IN TYPHOID FEVER.

By H. C. WOOD, M.D.*

THE latest and, in its clinical pathology, the best book for a student in the English language upon the practice of medicine is that of Professor Osler. The fact that a man can say, as Professor Osler says, in one of his recent papers, that he has notes upon a thousand post-mortems of phthisis, dictated by himself, shows that he has approached the practice of medicine through pathology rather than through therapeutics, a fact which ought to be borne in mind by every student while reading the sections on therapeutics in Professor Osler's work.

On page 37 of the book, in the discussion of the treatment of typhoid fever, occur the following words: "For tympanites, with a dry tongue, turpentine was extensively used by the older Dublin physicians, and it was introduced into this country by the late George B. Wood. Unfortunately, it is of very little service in the severer cases, which too often resist all treatment. The routine administration of turpentine in all cases of typhoid fever is a useless practice, for the perpetuation of which, in this generation, H. C. Wood is largely responsible." So far as the personal element of this quotation is concerned, if I had belief in its truth, I would be greatly exalted in my own opinion, for how great must that man be who can lead astray without effort a whole generation of the ablest men of this continent! The fact that a book which is probably going to be *the* text book for American medical students fails properly to explain the right use of turpentine in typhoid fever is a sufficient excuse for the appearance of a brief article upon such an old subject, while the personal statements of the text are warrant for my writing such an article, and also for my detailing a personal experience.

When a young man I had an attack of typhoid fever, and was attended by Doctor (now Professor) Da Costa. During convalescence my recovery was prevented by recurring diarrhœa, with evidences of intestinal indigestion. One day my uncle, the late Professor George B. Wood, then an old man, came to see me. He said, "Neither thee nor Dr. Da Costa has read my book."* I replied, "I have certainly read it." "Thee has not read it to any advantage, then," was the reply, "or thee would know that just in thy condition I prescribe turpentine. The intestinal symptoms are due to ulceration, and turpentine will heal the ulcers." With the consent of Dr. Da Costa, I took turpentine, and the intestinal symptoms rapidly abated. For experimental purposes, the turpentine was stopped, and the intestinal symptoms reappeared, only to disappear again when the turpentine was taken afresh; and so I experimented time and again, until it became perfectly clear that the turpentine had a specific influence upon my intestinal condition. After this its constant administration was followed by steady progress toward health.

This personal anecdote clinically portrays what I believe to be an important practical fact—namely, that when, in the convalescence of typhoid fever, the existence of local intestinal symptoms points toward slowness of healing of the ulcers, turpentine is an invaluable remedy.

The second class of cases in which the value of turpentine has been asserted most positively by hundreds of clinicians of large experience, many of them men of the highest renown as therapeutists, is that in which marked tympanites, with dryness of the tongue, develops in the end of the second week of typhoid fever. Possibly it may be well at this point to quote the exact words of Dr. George B. Wood in his "Practice of Medicine:" "But there is a particular condition, and that a not uncommon and sometimes a very dangerous condition, in which I have very often employed it, and hitherto have very seldom known it to fail. In the description of the symptoms, it was stated that, in the latter period of the disease, the tongue, instead of cleaning gradually from the edges and tip, often parts with its fur quickly and in large flakes, generally first from the middle or back part of the surface, which is left smooth and glossy, as if deprived of its papillæ. It was also stated that if, after this process, the tongue remains moist, a slow convalescence may be pretty confidently calculated on. But it not infrequently happens that, during the progress of the cleaning process, or after its completion, the surface of the tongue becomes quite dry, and the process, if not finished, is suspended. At the same time there is generally an increase of the tympanites, and an aggravation, or certainly no abatement, of the other symptoms." Dr. George B. Wood believed that the action of turpentine in these cases was a local one exerted upon the ulcerated surface, and gave good reasons for his belief. I have no doubt myself of the correctness of this theory.

Any one conversant with the literature of the subject must recognize that a great number of clinicians have endeavored in various ways to get in typhoid fever a local action upon the ulcerated surface of the intestines; for example, nitrate of silver has been largely employed and much lauded by Professor Pepper. The difficulty is that it is not possible to get most of these alterative substances in contact with the ulcers; thus, the alkalies of the saliva, the chlorides and organic matter in the stomach, and the alkalies of the intestinal juices must utterly destroy the quarter, or even half, of a grain of nitrate of silver before it can get through even the duodenum. Terebinthinates, are, however, slowly absorbed, and are, moreover, volatilized at the temperature of the stomach and intestines. When turpentine is freely and systematically given, it must as turpentine reach the small intestine, and must also fill with its vapors all the intra-intestinal spaces. The effects of terebinthinates upon ulceration is well known, and if credit is to be given to laboratory researches, there would seem to be a special relation between the oil of turpentine and the bacillus of typhoid fever. In a work which received the gold medal from the medical faculty of Kiew, Theodore Omelchenko detailed, among other things, the results which he arrived at in experiments with the bacillus of typhoid fever. He found that if the air were saturated with the vapors of turpentine and certain allied substances, the bacillus of the typhoid was destroyed, while a moderate amount of the turpentine vapor was able to arrest the development of the bacillus. It is true that he found certain other substances, especially thymol, more powerful than oil of turpentine; but the question in the past has not been between oil of turpentine and these substances, but as to the value of the oil of turpentine. It may be that in the future thymol will be found more active than turpentine; it is, however, much less volatile than turpentine; and, although volatilized thymol may be more active than the turpentine as a bacillicide, yet under the conditions found in the intestinal tract, the greater volatility of turpentine may make it practically the more efficient in destroying disease germs.

Too much importance must not, however, be attached to these laboratory experiments, which, at best, only afford an explanation of the clinical results. The survival of the use of turpentine in typhoid fever, through more than half a century, in spite of attacks upon it like this of Professor Osler, demonstrates the vitality of the practice, and proves that it cannot be dependent upon the favor or exertions of any one man or group of men.

Believing, as I do, that turpentine acts locally; that in all cases of typhoid fever ulceration exists; that properly administered the drug is incapable of doing harm, I am in the habit of giving toward the close of the second week of typhoid fever turpentine, without looking for special indications, and, as the result of an experience of considerably over a quarter of a century, I believe the practice to be a good one, and that the use of turpentine does distinctly tend to lessen the severity of the local lesions in enteric fever.

In closing this brief paper, may I call attention to the powers of glycerin in disguising the taste of turpentine, and give the following formula:

℞ Ol. terebinthinæ, f ʒ ii;
Glycerinæ, f ʒ i;
Mucil. acaciæ, f ʒ iss;
Aquæ menthæ piperitæ, q. s. ad f ʒ viii. M.

Sig.—Tablespoonful every four hours during the day. Shake well.—*The Therapeutic Gazette.*

* Professor of Therapeutics in the University of Pennsylvania.

* In his immediate family, Dr. George B. Wood always used the Quaker dialect.

DIPHTHERIA.

QUARANTINE AND DISINFECTION IN LIMITED APARTMENTS.*

By HENRY DWIGHT CHAPIN, M.D., Professor of Diseases of Children at the New York Post-Graduate Medical School and Hospital.

PROBABLY in no other condition of the practice of medicine is the difference between sound theory and actual practice so painfully exemplified and contrasted as in trying to treat a case of diphtheria in tenements and small apartments. The physician may give his orders plainly, but he knows it is impossible to have them carried out with any degree of efficiency. The rooms are probably small and so arranged that one communicates with another in such a way that it is very difficult to isolate any one of them. Still, the greatest isolation possible under the circumstances must be sought, and an end room will serve the purpose best. In many small apartments, the parlor is the only room unoccupied at night, and hence may be selected as the sick room, particularly as it is apt to be large and airy compared with others. The health and even the life of other children must be the argument used in favor of taking the best room for this purpose.

All superfluous articles having been removed, a sheet, wet with some disinfecting solution, may be tacked on the outside of the door. It may be stated at the outset that these few remarks are written more from the practical than from the bacteriological standpoint. While it is not contended that a sheet occasionally so wetted is a germ-proof barrier, it yet serves a purpose in more completely shutting in the sick room, and serving as a sort of danger signal to those without.

If possible, some adult member of the family may act as nurse, in the mean time not mingling with the others. Where the mother has to do all the work, she should have a loose wrapper to draw on in the sick room, discarding it upon her exit. I believe it is better to have the patient upon a cheap cot that can be thoroughly cleansed or destroyed rather than upon a bed or sofa that it will be hard to free of germs.

The room should be kept warm enough to allow a constant supply of fresh air, procured by dropping one of the windows a little from the top. This will not only have a favorable effect upon the patient, by diminishing the chances of his own reinfection, but lessen the risks of the attendant.

Some believe they have seen good effects produced by the constant evaporation from boiling water to which such disinfectants as turpentine, carbolic acid and eucalyptus have been added. This process certainly adds to the agreeableness of the air in the room, and the moisture may not be without benefit to the patient.

While as complete isolation of the infecting agent as possible must be secured, the destruction of the infective virus *at its source* will be necessary in order to secure the benefits of an effective quarantine. The pathogenic micro-organism of diphtheria is now pretty generally recognized as the Klebs-Loeffler bacillus, which exists abundantly in the diphtheritic exudate but is not found in the organs and secretions of the body. As the seat of the diphtheritic exudate is, in the majority of cases, the throat and nose, the problem of the destruction of the infective virus is not so complicated as in some other infective diseases. If, however, this virus is not quickly destroyed at its source, the disease will be spread by its property of adhering tenaciously to many objects with which it is brought in contact. It is hardly necessary to enumerate the clothing, toys and books of the patient, sheets, blankets, and bedding, and various articles of furniture in the room as objects which may quickly and easily become contaminated and perhaps long afterward communicate the disease.

The more the poison of diphtheria is allowed to become diffused, the greater will be the difficulty of controlling the spread of the disease by really efficient disinfection. Diphtheria will prove slightly contagious or widely contagious, according as active means are taken to destroy the virus as much as possible at its source or allow it to become generally diffused. It must be remembered that in diphtheria we are dealing with both an infectious and contagious disease, inasmuch as it is originally caused by the invasion and reproduction of pathogenic microbes within the body, and that such microbes may be communicated from the diseased to a healthy body, starting a fresh attack of the disease *under the common conditions of life;* but that the degrees of this contagiousness or communicability can be influenced by the physician's art, and it is his duty to exert all the influence known to science in such a direction.

The direct contagion from diphtheria is limited to a small area, probably in most cases not more than a few feet from the patient. As the bacilli are situated principally in the superficial parts of the exudate, every effort must be made to disinfect *in situ* and thus destroy the contagium before it has opportunity to infect other bodies. I believe that if more attention were given to careful disinfection of the pseudo-membranes, and less to trying to dissolve or destroy them, the results would be better both for the patient and the other members of the family. To this end, however, no drug must be used in sufficient concentration to be locally irritating. A solution of carbolic acid in lime water, 1 to 200, or corrosive sublimate, 1 to 4,000, employed frequently as a spray or gargle, are valuable applications for the throat. Both may sometimes be safely used in stronger concentration; but, as a rule, it is better to use a weaker solution often. The frequent doses of tinct. ferri chlorid. and glycerin so commonly employed in the constitutional treatment of diphtheria have a valuable local effect in disinfection as well. For the nose, which is highly sensitive, frequent irrigation with boric acid. The solution must always be warm. These disinfecting applications should be made as a rule every two hours, and in bad cases oftener. Much tact will have to be exercised in being as thorough as possible without unduly annoying or exhausting the child.

While these efforts will reduce to a minimum the diffusion of diphtheritic virus, it is impossible entirely to prevent such a spread. They must hence be supplemented by a disinfection of all the objects with which

* Read before section on pædiatrics, New York Academy of Medicine. From *Merck's Bulletin.*

the patient is brought in contact. The greatest danger being in the discharges from nose and mouth, old rags or bits of cheese cloth, after serving as handkerchiefs, must at once be burned. This valuable precaution can be easily taken in the most restricted apartments, and yet is often neglected. All clothing, bed linen, etc., that has been in contact with the patient, can be soaked in the solution recommended by the board of health, *i. e.*, sulphate of zinc 4 ounces, common salt 2 ounces, to a gallon of water. This solution is cheap and easily procured, and should be kept constantly standing in the room. Spoons, cups and all feeding utensils can likewise be soaked in this solution, but all articles, after being taken out, must be subjected to thorough boiling.

When the case has ended, either in recovery or death, as complete a cleansing and disinfection as possible of the room and its furniture must ensue. All suitable articles must be soaked in the zinc solution and then boiled. Quilts, comforters, pillows, etc., may be thoroughly shaken on the roof and then exposed for hours to the fresh air and sunlight. The two latter factors form the most harmless but complete disinfectants that are known. The furniture, floors, walls and ceiling may be washed with carbolic acid, 1 to 20, or corrosive sublimate, 1 to 1,000. These two reliable disinfectants frequently fail because of too weak a solution. The same preparation may be used to flush out sinks and water closets, as it is best not to multiply solutions. If the walls are papered, they may be rubbed down with stale bread crumbs, which bacteriologists have taught us collect the germs. The same may be done to the ceiling.

With reference to sulphur fumigation, while bacteriologists state that the fumes of sulphurous acid do not destroy spores, it has always seemed to me well to employ this procedure when possible. It certainly has the effect of sweetening the air of a room, at least, and some practical workers in boards of health think it does good. A free application of moisture in the room increases its efficacy. The thorough airing required after the combustion of sulphur in a room may be a not unimportant factor contributing to its good effect. Cultures made with the bacillus of diphtheria have been found virulent after five months' retention. Hence we can readily understand how tenaciously the poison clings to a room that has not been thoroughly cleansed and disinfected.

When diphtheria invades a family living in a limited apartment, where complete isolation is difficult if not impossible, the remaining children should be removed if there is any place to take them, until the illness is over, and the quarters have been disinfected. This, however, is just what cannot possibly be done in the great majority of instances, as no one wishes to harbor these poor children. To meet this dilemma, the recent report of the committee on hygiene of the New York County Medical Society suggests that stations or refuges be established where such children could be housed until the sick at home have either recovered or been removed and the domicile disinfected. Houses arranged for such purposes ought to contain common dormitories, and private rooms for such as could afford to pay for better accommodations. If the city authorities could be induced to establish a few such houses in various sections, under the control of the board of health, who would transport the cases upon notice from a physician, much good would be done.

Where the children *must* remain exposed, a constant irrigation or spraying of the throat with corrosive sublimate, and of the nose with boric acid solution, will aid in preventing infection. It is supposed that Loeffler's bacillus will not cause diphtheria when brought in contact with a healthy mucous membrane, and hence any agent that will cleanse and protect an exposed surface will help to prevent disease. It is also well to administer tinct. ferri chlorid. as a tonic.

27 West 51st St., New York City.

METALLIC CARBONYLS.

MR. LUDWIG MOND, F.R.S., recently lectured at the Royal Institution on "Metallic Carbonyls," in the course of which he dealt with the subject of the extraction of metallic nickel from rich and poor ores, by means of carbonic oxide. We follow the report in *The Engineer*.

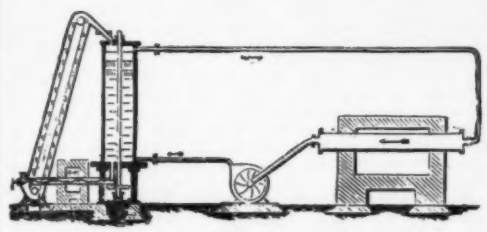
Mr. Mond said that, so long ago as 1834, Justus Liebig proclaimed carbonic oxide to be a chemical radical, and that two years ago he—the speaker—announced to the Chemical Society, in conjunction with Drs. Langer and Quincke, that carbonic oxide gas combines at ordinary temperatures with so inactive an element as nickel, and forms a well defined compound therewith, of exceedingly peculiar properties. The paper published by Liebig in 1834 was entitled "On the Action of Carbonic Oxide on Potassium," in which he fully described the preparation and properties of the first metallic carbonyl known, the compound of potassium and carbonic oxide formed by direct action at a temperature of 80 deg. C., and proved it to be identical with a dangerous by-product in the manufacture of potassium from potash and carbon by Brunner's method. It forms a non-volatile gray powder, which with water yields a red solution gradually turning into potassium croconate, a salt which contains no hydrogen. The formula of potassium carbonyl is $K_4C_6O_6$.

It seems surprising that others should not have followed up Liebig's work, by attempting to obtain other metallic carbonyls. Lithium and calcium are stated to combine with carbonic oxide, but metals of other groups have received little attention. The important part which carbonic oxide plays in the manufacture of iron, indeed, did lead Sir Lowthian Bell, Dr. Alder Wright, and others, to study its action upon metallic iron and other heavy metals, including nickel and cobalt at high temperatures; they proved that these metals split up carbonic oxide into carbon and carbonic acid at a low red heat. None of them tried to obtain compounds of these metals with carbonic oxide, and, owing to the high temperature and other conditions under which they worked, the existence of such compounds could not come under their observation.

To obtain them the metals must be in an extremely fine state of division, and must be treated with carbonic oxide at a low temperature. The best results are obtained when the oxalate of the metal is heated in a current of hydrogen, at the lowest temperature at which the reduction to the metallic state is possible.

Mr. Mond here passed a slow current of carbonic oxide through a tube gently heated, and containing finely divided metallic nickel; after passing over the metal, the gas when ignited burnt with a highly luminous flame, due to incandescent metallic nickel separated in the flame from nickel carbonyl. When the nickel carbonyl falls upon any solid heated but to 200 deg. C., the solid is coated with bright metallic nickel, and carbonic oxide is liberated. He passed also the nickel carbonyl through a tube surrounded by a freezing mixture, in which tube a colorless liquid condensed, which could be sealed up therein. It is pure nickel carbonyl Ni $(CO)_4$. Its specific gravity at ordinary temperatures is 1·385, and it boils under atmospheric pressure at the low temperature of 43 deg. C. At ordinary temperature it has a high vapor pressure, and possesses a high rate of expansion. When cooled to −25 deg. C. it solidifies, forming needle-shaped crystals. A mixture of the vapor with air explodes readily, sometimes at ordinary temperature, but without violence, as he proved by experiment, by means of such quantity as was held by a tall narrow cylindrical glass jar. The liquid in the pure state does not explode, but decomposes into its constituents when heated sufficiently. The vapor of nickel carbonyl possesses a characteristic odor, and is poisonous, but not more so than carbonic oxide gas. Prof. McKendrick has studied the physiological action of the liquid, and found that when injected subcutaneously in rabbits, it produces an extraordinary reduction of temperature, in some cases as much as 12 deg. The liquid can be completely distilled without decomposition, but from its solution in liquids of a higher boiling point it cannot be obtained by rectification. On heating such a solution the compound is decomposed, nickel being separated in the liquid, which it makes completely black, while the carbonic oxide gas escapes. Mr. Mond proved this by heating a solution of nickel carbonyl in heavy petroleum oil.

When nickel carbonyl is attacked by oxidizing agents, such as nitric acid, chlorine, or bromine, it is readily broken up, nickel salts being formed and carbonic oxide liberated. Sulphur acts in a similar way. Metals, even potassium, alkalies, and those acids which have no oxidizing power, will not act upon the liquid at all; neither will the salts of other metals. By exposing the liquid to atmospheric air, a precipitate of carbonate of nickel is slowly formed, of varying composition, according to the hygroscopic state of the air. All these precipitates dissolve easily in dilute acid, with evolution of carbonic acid, leaving ordinary nickel salts behind. Professor Berthelot has described a beautiful reaction of nickel carbonyl with nitric oxide; an intense blue coloration is given when nitric oxide is



passed through a solution of nickel carbonyl in alcohol.

Professor Quincke, of Heidelberg, has found nickel carbonyl to be very diamagnetic. All other nickel compounds are paramagnetic. He also found it to be almost perfect non-conductor of electricity. Professors Dewar and Liveing are investigating its absorption and flame spectra. They have found that it is opaque for all the rays beyond the wave length 3,820. Its flame gives a quite continuous spectrum.

Mr. Mond here drew attention to the following principal physical properties of nickel carbonyl:

Physical constants.

	Nickel carbonyl.	Ferro-penta-carbonyl.
Specific gravity	1·3185	1·466
Boiling point	43 deg. C.	102·8 deg. C.
Melting point	−25 deg. C.	−21 deg. C.
Molecular weight	170	196
Vapor density	6·01	6·5
Coefficient of expansion	0·0018	
Coefficient of dispersion	1·1236	
Molecular refraction $\frac{\mu}{D}$	58·63	69·30
Magnetic rotary power	38·21	
Diamagnetic constant	$-3·131 \times 10^{19}$	

Di-ferro-hepta-carbonyl Fe_2 (C O)$_7$, mol. weight 308.

Dr. W. H. Perkin has investigated the power of magnetic rotation of nickel carbonyl, and found it to be, with the sole exception of phosphorus, greater than that of any other substance he has yet examined. Mr. Mond stated that he had investigated in Rome the refractive and dispersive powers of nickel carbonyl, in conjunction with Professor Nasini, and they found the atomic refraction to be nearly two and a half times as large as in any other nickel compound. He then performed an optical experiment proving nickel carbonyl to have great refractive and dispersive power. The atomic refraction of a liquid compound of iron with carbonic acid has been determined by Dr. W. H. Gladstone, who found it to bear about the same ratio to the atomic refraction of iron in its other compounds. The ferro-carbonyl is prepared in a similar manner to the nickel compound. The iron used is obtained from the oxalate, at the very lowest temperature possible, and is in a high degree pyrophoric; it immediately catches fire on coming into contact with the air. This carbonyl is formed with great difficulty, and careful precautions have to be taken to obtain even a small quantity; it is an amber colored liquid, it solidifies below −21 deg. C., and its specific gravity is 1·466 at 18 deg. C. On heating the vapor to 180 deg. C. the iron is thrown down in bright mirror-like form, and the carbonic oxide escapes. Its chemical composition is Fe (C O)$_5$.

Within a short time after they had made known the existence of iron carbonyl, Sir Henry Roscoe found it in carbonic oxide which had been compressed in an iron cylinder, and expressed the opinion that it forms the red deposit sometimes found upon steatite gas burners. Its presence in the compressed gas used for the lime light has been noticed by Dr. Thorne, whose attention was called to the fact that this gas sometimes will not give a proper light because the incandescent lime becomes covered with oxide of iron. M. Garnier supposes even that iron carbonyl is formed in large quantities in blast furnaces when they are working too cold, and refers to some instances in which he found large deposits of oxide of iron in the tubes leading away from these furnaces, but Mr. Mond finds it difficult to believe that the temperature of the blast furnace ever falls sufficiently low to permit the formation of the compound. Possibly carbonic oxide may play an important part in the cementation process of making steel.

The iron carbonyl behaves to acids and oxidizing agents as does nickel carbonyl, but it dissolves in alkalies without evolution of gas, and in time a greenish precipitate falls, consisting chiefly of hydrated ferrous oxide; the liquid becomes brown on exposure to the air; it then takes up oxygen, and hydrated ferric oxide is precipitated.

Ferro-penta-carbonyl remains perfectly unchanged in the dark, but if it is exposed to sunshine, it is changed into a solid body of remarkably fine appearance, of gold color and luster, as shown by a sample on the lecture table. This solid body is not volatile, but on heating it in the absence of air, iron separates, and liquid ferro-carbonyl distills over. By careful heating in a current of carbonic oxide, it is reconverted into the ferro-penta-carbonyl, and completely volatilized. No solvent has yet been found for this substance, therefore no means of obtaining it in a perfectly pure state. Its formula is approximately Fe_2 (C O)$_7$, or di-ferro-hepta-carbonyl.

The discoverers then tried, as Lord Kelvin once put it to Mr. Mond, "to give wings to other heavy metals." They have tried all the well-known and a great many of the rarer metals without success, with the exception of nickel and iron. Even cobalt, which so much resembles nickel, has yielded no trace of a carbonyl.

Mr. Mond then tried to extract nickel from its ores industrially by means of carbonic oxide. For solving this problem within the limits of the resources of a laboratory the discoverers devised apparatus, the principles of which are shown in the accompanying diagram. It consists of a cylinder divided into many compartments, through which the properly prepared ore is passed very slowly by means of stirrers attached to a shaft. On leaving the bottom of this cylinder, the ore passes through a transporting screw, and from this to an elevator which returns it to the top of the cylinder, so that it passes many times through the cylinder until all the nickel is volatilized. Into the bottom of this cylinder carbonic oxide is passed, which leaves it at the top charged with nickel carbonyl vapor, and passes through the conduits represented, into tubes set in a furnace, and heated to 200 deg. C. Here the nickel separates from the nickel carbonyl. The carbonic oxide is regenerated and taken back to the cylinder by means of a fan, so that the same gas is made to carry fresh quantities of nickel out of the ore in the cylinder, and to deposit it in the tubes an infinite number of times. Upon these principles Dr. Langer has constructed a complete plant on a Liliputian scale, which has been at work in Mr. Mond's laboratory for a considerable time. The volatilizing cylinder is divided into numerous compartments, through which the ore passes. The carbonic oxide gas is prepared in any convenient manner. When it comes out at the top of the cylinder, it passes through a filter to catch any dust it may contain.

The carbonic oxide, on escaping from the depositing tubes, is passed through another filter, thence through a lime purifier to absorb any carbonic acid which may have been formed. The whole of this miniature plant is kept in motion by means of an electric motor. By means of this apparatus nickel has been extracted from a great number of ores, in times varying, according to the nature of the ores, from a few hours to several days.

Before the end of this year this process is going to be established in Birmingham, on a scale which will place its industrial capacity beyond doubt, and Mr. Mond expects nickel carbonyl to play an important part in metallurgy. The process, he says, possesses, besides its great simplicity, the additional advantage that it is possible to immediately obtain the nickel in any definite form. If deposited in tubes, nickel tubes are obtained; if deposited in a globe, a nickel globe results; if deposited in any heated moulds, copies of these moulds are yielded in pure, firmly coherent, metallic nickel. The metal thus deposited reproduces the most minute details of the surface of the mould to fully the same extent as a galvanic reproduction, so that all the numerous objects which Mr. Swan recently exhibited at the Royal Institution in large and beautiful variety can be produced by the carbonyl process with the same perfection in pure metallic nickel. It is equally easy to nickel plate any surface which will withstand the temperature of 180° C. by heating it to that temperature, and exposing it to the vapor, or even a solution of nickel carbonyl, a process which in many cases may have an advantage over electro-plating.

On the Royal Institution lecture table were specimens of nickel ores used in the process, also tubes and plates obtained from the ores, also a few specimens of articles of pure nickel, likewise articles plated with nickel, all produced in Mr. Mond's laboratory.

These, he said, would give some idea of the prospects which the process opens out to the metallurgist, upon whom from day to day greater demands are made to supply pure nickel in quantities. The most valuable properties of the alloy of nickel and iron, called nickel steel, which promises to supply us with impenetrable ironclads, have made an abundant and cheap supply of this metal a question of national importance. The inspection of the specimens on the table, he hoped, would suffice to demonstrate the great facilities the process offers for producing fine copies, and for making articles of such forms as cannot be produced by hydraulic pressure, the only method hitherto available for making articles of pure nickel. He also drew attention to a small coiled pipe made by the process, lent by Prof. Ramsay, which was of interest as the first article made in this way for a chemical laboratory.

PHOSPHORUS MIRABILIS.

By VAUGHAN CORNISH, B.Sc., F.C.S.

ANY substance capable of shining in the dark was originally termed a *phosphorus*. Several substances having the property were known as early as the middle of the seventeenth century, such, for instance, as barium sulphide, the "Bononian Phosphorus," to which may be added the sulphides of calcium and strontium. The power of barium sulphide and similar bodies to *phosphoresce* depends upon their being previously exposed to light. When a ray of light falls on any substance, part is reflected and part absorbed. As long as the body is exposed to the ray of light it is itself a source of luminous disturbance, and consequently a visible object. The peculiarity of substances such as the sulphides of the alkaline earths is that they continue to be a source of luminous disturbance for a time, when no longer exposed to the ray of light. This power of a body to store up and slowly dole out the luminous vibrations it receives is called, in physical optics, *phosphorescence*.

Bodies having this property are termed phosphorescent bodies.

Of all substances luminous in the dark, common yellow phosphorus is the best known, and the example which most people would cite as that of the typical phosphorescent body. Singularly enough, the causes which induce the glow of the chemical element phosphorus are altogether distinct from those we have mentioned as the cause of phosphorescence in barium sulphide and similar bodies. The terminology of the subject has undergone a peculiar alteration since the seventeenth century. At that time any substance capable of shining in the dark was called "a phosphorus." Now, the name phosphorus is restricted by chemists to one chemical element. The element in question exists in more than one allotropic modification, and one of these forms (red or amorphous phosphorus) does not shine in the dark.

While, on the one hand, chemists have made the term phosphorus special instead of generic, physicists usually apply the term phosphorescent to a whole class of substances; but "phosphorus" does not belong to this class.

In the present article we will give a short sketch of the investigations which have been made into the subject of the "Glow of Phosphorus." Ordinary yellow phosphorus was first prepared by an alchemist of Hamburg named Brandt, and in spite of the care with which the secret of its preparation was guarded a number of persons soon became possessed of the method of manufacture. The early methods, however, gave but a small yield, and were so difficult to carry out that the substance remained for long an extremely expensive chemical curiosity. Its many remarkable properties were a favorite subject for exhibition among the learned and curious, and earned for Brandt's product the name of the *phosphorus mirabilis*. Robert Boyle observed that the *phosphorus mirabilis* differed from other shining bodies in that its luminosity did not depend upon its being previously exposed to light. Subsequently it was observed that if phosphorus were brought into the vacuous space above the mercury in a barometer tube, the body no longer shines in the dark. It seemed probable, therefore, that the glow was induced by the presence of air. As in most phenomena in which air takes part oxygen is the active agent, it appeared likely that the glow was due to some action between the phosphorus and the oxygen of the air. It was found that in pure oxygen phosphorus at the ordinary temperature and pressure did not glow at all. The glow can, however, be induced either by "partially exhausting" the oxygen in the vessel (*i. e.*, by diminishing the pressure) or by raising the temperature. If, after the latter means had been adopted, the oxygen were compressed, the glow again disappeared. Now, at the ordinary temperature phosphorus volatilizes or evaporates at a very appreciable rate. From these facts, therefore, it seemed probable that the glow was due to an action between the vapor of phosphorus and oxygen, the two factors essential for the production of the glow being the presence of oxygen and conditions favorable to evaporation. The correctness of this conclusion is well shown by the following facts. If phosphorus be placed in hydrogen, or in carbonic acid, no glow is seen, but traces of phosphorus vapors can readily be detected in the gas. When one of these gases charged with the vapor of phosphorus is brought into contact with oxygen gas, a glow is at once observed. This glow is stronger in the case of hydrogen than when carbonic acid is used, which is in accordance with the fact that phosphorus evaporates more readily in an atmosphere of the lighter gas.

It appears that the glow of phosphorus in oxygen is in some way connected with the presence of ozone.

It is a well known fact that when a stick of phosphorus is placed in moist air, ozone is produced, and it has further been observed that if a drop or two of ether, or oil of turpentine, substances which destroy ozone, be placed in the ozonized air of a vessel containing a piece of the phosphorus, the glow of the phosphorus is at once quenched.

It appears probable that the glow is nothing else than a very feeble flame, which may be seen when circumstances are favorable to the oxidation or burning of the phosphorus. If the temperature be raised to a moderate degree the combustion takes place with greatly increased energy, and we get the ordinary flame of burning phosphorus. Recently Professor Thorpe, and other workers of the Royal College of Science, have investigated a similar case of phosphorescent appearance due to oxidation. This occurs with the *trioxide* oxide of phosphorus.

When phosphorus is burnt in a rapid current of air, one of the principal products is the trioxide, which is capable of combining with a further dose of oxygen, forming the better known and more stable substance, pentoxide of phosphorus.

The phenomena accompanying this oxidation of the lower oxide (the trioxide) have of late been carefully studied. A phosphorescent appearance is observed when oxidation occurs, and it has been found possible, by varying the conditions of temperature and of pressure, to pass insensibly from the feeblest glow to the most brilliant combustion.

The trioxide is a more volatile body than phosphorus itself, and better adapted for experiments to show the gradual passage from the "degraded combustion" of the "glow" to the ordinary burning with visible flame.

There are other well known appearances besides those presented by phosphorus, which are due to degraded combustion; one example is furnished by the feeble lambent flame seen *inside* the wire gauze of a Davy lamp in "fiery" parts of a coal mine. The conducting power of the wire gauze distributes the heat of the flame over a large area, and prevents the inflammable gas outside the lamp from becoming heated to the point at which explosion occurs.

The *ignis fatuus* is quoted as a still more striking example of the *degraded* combustion of an inflammable gas. Marsh gases, the slow combustion of which is seen in the feeble flame of the will-o'-the-wisp, consists largely of methane, or fire damp, the explosive gas of mines.

Their slow oxidation (or degraded combustion) by the air of the marshes produces at night time a faint glow of uncertain or shifting position, to whose misleading light have been attributed difficulties of the road, as many as have beset the search of scientific men after the true cause of the glow of phosphorus.—*Knowledge.*

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